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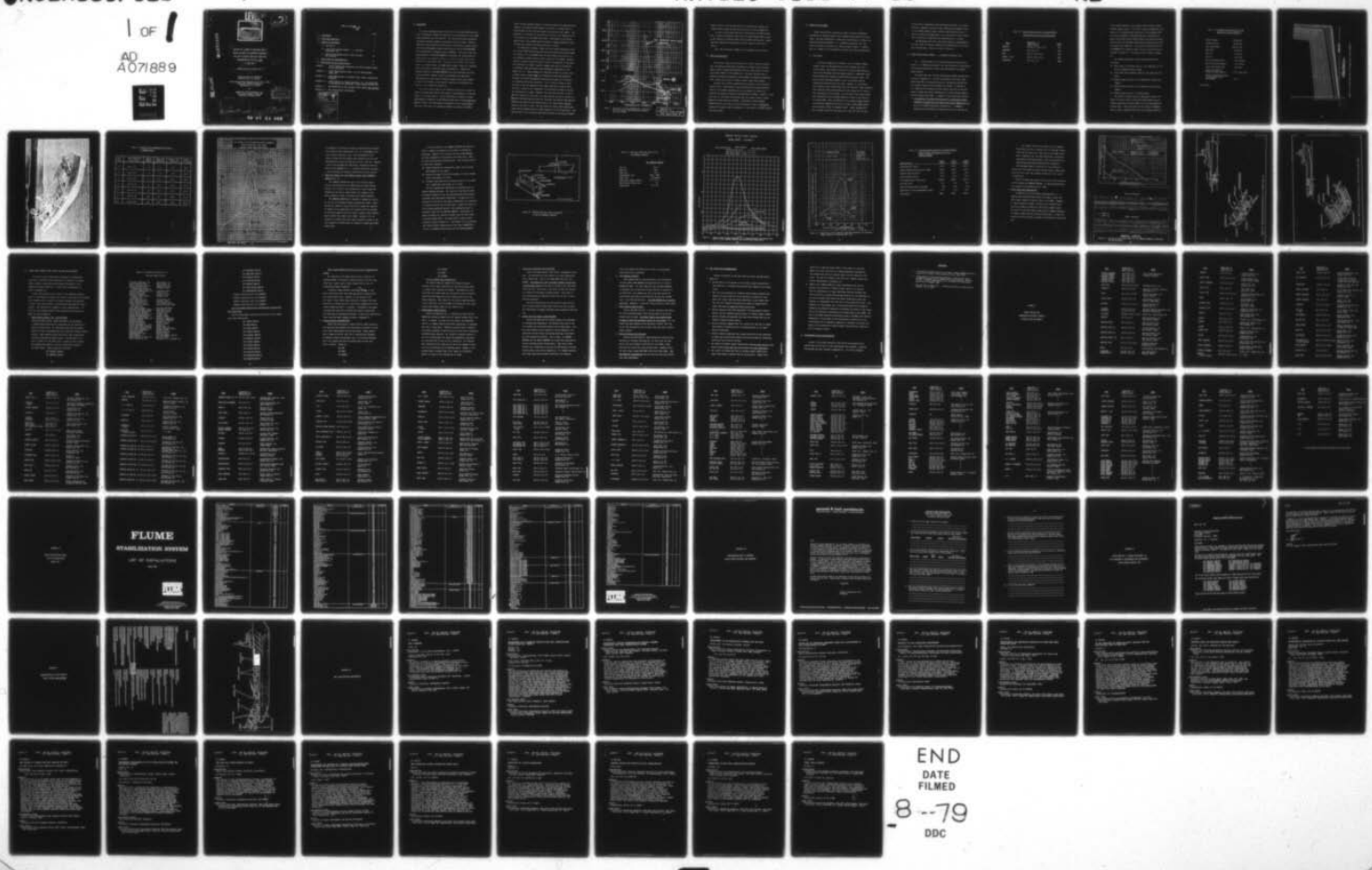

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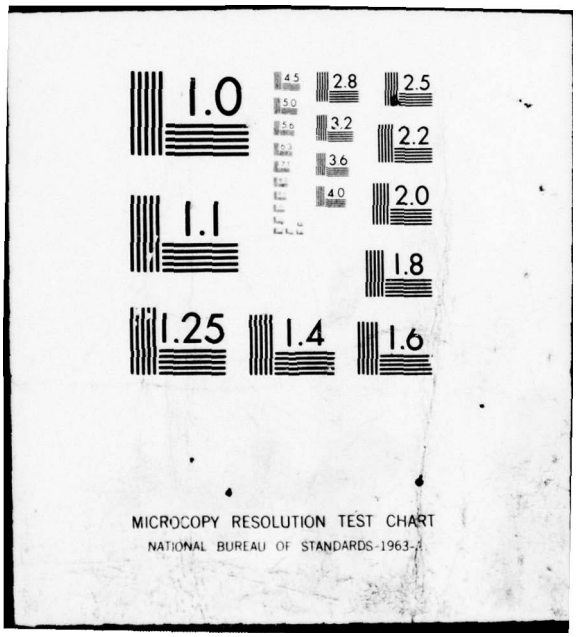
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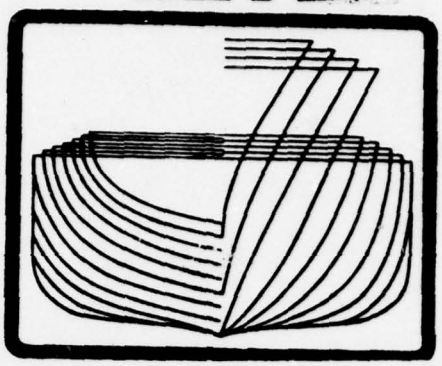

RESULTS OF A SURVEY OF OFFSHORE SUPPLY VESSEL BUILDERS AND OPERATORS CONCERNING THE USE OF PASSIVE ANTI-ROLL TANKS AND RECOMMENDATIONS FOR THE T-AGOS.

23 MAY 1977

NAVSEC Report No. 6136-77-19

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1.0 BACKGROUND

A recent seakeeping study conducted for the T-AGOS hard chine hull (ref. 1) presented results of analytical roll predictions for the T-AGOS with and without anti-roll devices. Two such devices were considered: paravanes ("flopper stopper") and passive anti-roll tanks. Previous experience with paravanes has been mainly restricted to fishing vessels and a few oceanographic research ships such as the R/V CAPE HENLOPEN of the University of Delaware and the SCORPIUS. Full scale tests have been conducted on the CAPE HENLOPEN to determine the effectiveness of these devices in reducing roll but the results of these tests are not available at the present time. Furthermore the installation of paravanes on a larger vessel, the MOANA WAVE (length = 158.36 ft, displacement = 950 tons) is presently under consideration. Pending the analysis results of the CAPE HENLOPEN tests with paravanes installed it was decided to conduct a study to investigate the experience with passive anti-roll tanks in offshore supply vessel hulls similar to that of the T-AGOS. A few remarks regarding the background and need for this information follow next.

For a hull such as that of the T-AGOS the natural roll period is about 9 seconds which falls in the region of peak energy of a high Sea State 5 or low Sea State 6. If the T-AGOS were to operate in these environmental conditions at 90^{o} heading (beam seas) it would experience severe rolling. The operational requirements for the vessel dictate that up to Sea State 4 no change in heading is allowed so that the

worst rolling situation would be a beam sea condition in that sea state. However, the period of peak energy in Sea State 4 is about 6.5 to 7 seconds which is less than the natural roll period of the vessel. Consequently, in Sea State 4 the excitation in roll is not expected to be as critical as in the higher sea states. Furthermore in sea states greater than 4 the T-AGOS would be allowed to change heading away from the beam sea condition and thus avoid severe rolling.

An inspection of figure 1 shows the roll response amplitude operator of the T-AGOS double chine hull with and without anti-rolling tanks. In reference (1) it was shown that the peak energy of Sea State 4 is at a different period from the natural period of the T-AGOS. Recognizing that a passive anti-roll tank can reduce the magnitude of the peak roll response of a vessel, several attempts were made at arriving at a conceptual tank which would yield substantial reductions in roll angle (ref. 1). These attempts are reflected by RAO's A, B and C each of which yield a reduced peak roll response but each with different frequency of period distribution characteristics which is of interest for computing the motion statistics. As it turned out tanks A and B resulted in rms and significant roll angle reductions of about 19% in Sea State 4 which is not considered to be substantial enough to justify the installation of tanks. However, since the objective was to reduce the roll response in Sea State 4 the next obvious step was to arrive at a Response Amplitude Operator which not only gave the reduced roll response peak but one which had the desired shape in the region where the peak energy of Sea State 4 lied. The end result was tank C which indeed gave larger rms and significant roll angle reductions of 45% in beam seas. Having arrived at this conceptual tank based entirely on its desired dynamic

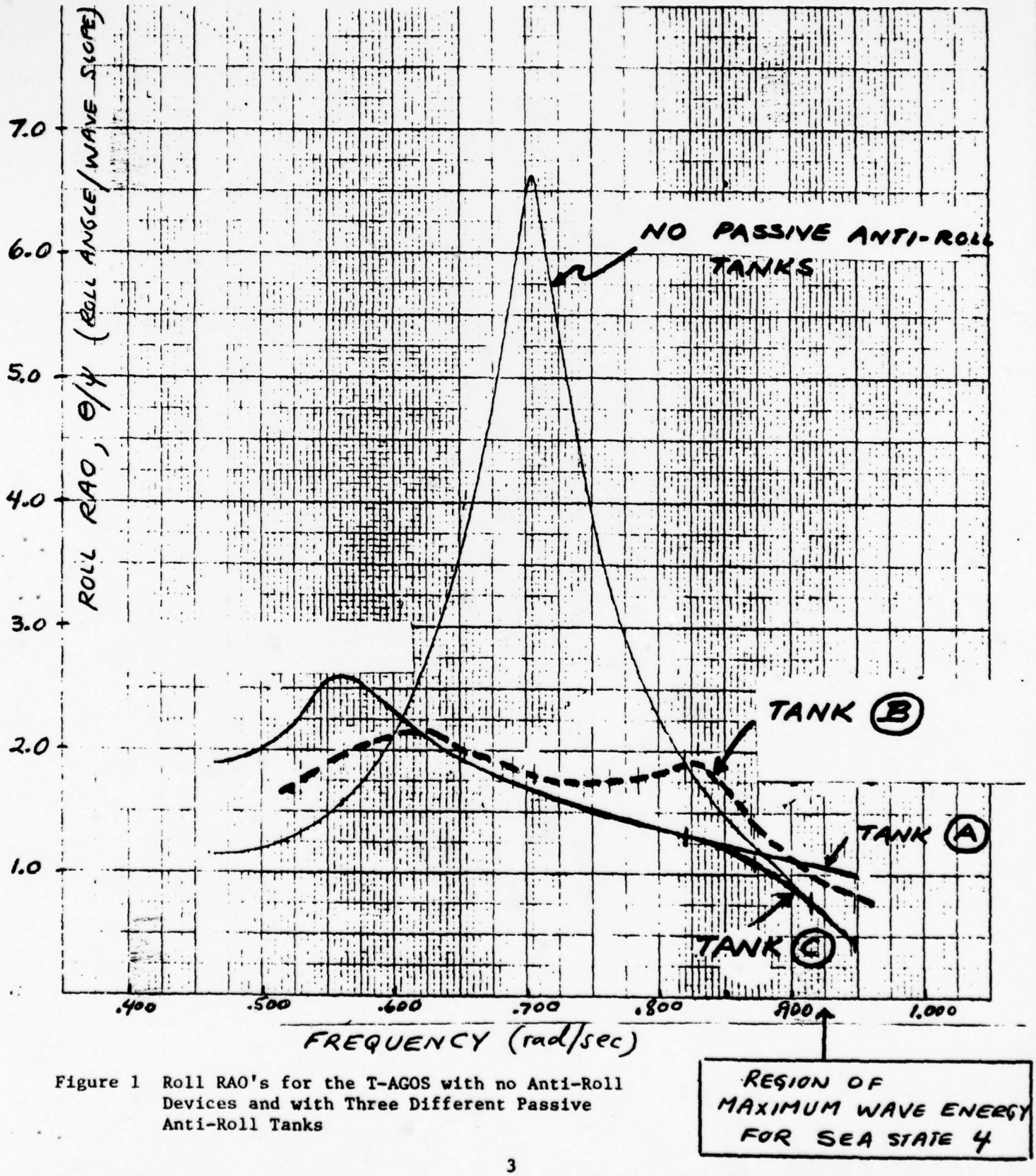


Figure 1 Roll RAO's for the T-AGOS with no Anti-Roll Devices and with Three Different Passive Anti-Roll Tanks

characteristics, the next step would be to design this tank for the T-AGOS without paying serious space and static stability penalties.

In view of these observations and calculations it became evident that a useful and necessary input into the T-AGOS design effort would be the opinion of offshore supply vessel builders and operators regarding their experience with passive anti-roll tanks in this type of vessel.

This report presents a summary of the findings of this survey.

2.0 SCOPE AND OBJECTIVES

The overall scope of this survey was to obtain specific information concerning the operational experience of double chined offshore supply vessels equipped with passive anti-roll tanks and of size and proportions similar to the T-AGOS hull. The main objective was to establish the general consensus of the builders and operators regarding their feeling for the use of tanks in double chined hull designs.

Builders and operators approached were limited to the continental United States. Limitations of time and funds did not permit personal visits to the vessels surveyed nor was it possible to contact all builders and operators listed in the ABS Record of Ships. However, it was felt that by contacting those groups with the largest fleets a representative sample would be achieved. Furthermore, actual onboard observations of sea trials or routine operation of any of the vessels equipped with tanks could be arranged at a later date if further detailed data were needed.

3.0 RESULTS OF THE SURVEY

Several sources were consulted in order to obtain the desired information on offshore supply vessels equipped with passive anti-roll tanks. The most significant of these were the ABS Record of Ships, the Flume Stabilization Systems of J. J. McMullen Associates, Inc. and various builders and operators of offshore supply vessels. Presented next is a summary of the information obtained from these organizations.

3.1 ABS RECORD

The first attempt was to develop a list of offshore supply vessels listed in the ABS Record as being equipped with anti-rolling tanks. This however proved to be totally unsuccessful as none of the 380 ships listed as Supply Vessels or Combination Tug/Supply Vessel were listed as having passive anti-roll tanks. The Record usually indicates whether or not a particular ship is equipped with passive anti-roll tanks. However, it is possible that offshore supply vessels which have had anti-roll tanks installed after they were built and delivered to their owners do not reflect this information in the listing. In fact some of the vessels which were identified later as having tanks were listed in the Record as not having them. Also, in addition to the category Supply Vessels or Combination Tug/Supply Vessels it is quite likely that several may be listed as "Tug" or "General Cargo". These, however were not screened as part of this survey as it was felt that the next

two sources of information would yield better results. For future reference, Appendix I gives the name, dimensions and owner of each of the offshore supply vessels listed in the ABS Record, none of which are listed as having tanks. At a later date it may be desirable to find out if tanks have been installed on any of them.

The ABS Record did list a few Survey Vessels in approximately the size range of interest, probably with molded hulls, fitted with anti-rolling tanks. These are listed in Table 3-1.

3.2 FLUME STABILIZATION SYSTEMS, J. J. McMULLEN ASSOCIATES, INC.

Mr. J. Gordon Cheyne of the Flume Stabilization Systems Division of J. J. McMullen Associates, Inc. was contacted for the purpose of obtaining information on Flume tank installations on offshore supply vessels.

The April 1976 list of Flume Stabilization System installations is given in Appendix II. Of this list several of the ship types listed appeared to be possible sources of information, specifically the research vessels and the offshore oil vessels. A request to J. J. McMullen for motions sea trials and/or test data for specific vessels yielded very little information for chined offshore supply vessels equipped with tanks. A summary of this information follows:

1. Investigation of Rolling Characteristics of Exploration Vessel "RAYMOND M" Equipped with the Flume Stabilization System (ref. 2)

   This is a December 1966 report prepared by J. J. McMullen Associates for the Mobil Oil Corporation and it is the only set

Table 3-1 Survey Vessels Listed in the ABS Record Fitted with Passive Anti-Rolling Tanks

NAME	DIMENSIONS, ft (LWL x B x T)	OWNER
BARTLETT	191.29 x 37.29 x 21.55	USN
CHAUVENET	357 x 54 x 31	USN
KANE	261.75 x 48 x 23.54	USN
SAMUEL P. LEE	191.29 x 39 x 21.55	USN
RESEARCHER	245 x 51 x 25	NOAA

of data made available by that company which concerns chined offshore supply vessels. The report presents regular wave test results of a testing program conducted at the Davidson Laboratory for the purpose of verifying the basic calculation of phase relation and fluid transfer within the tank and determining the effect of the Flume Stabilization System upon the ship in various wave conditions. The principal characteristics of the RAYMOND M are listed in Table 3-2 and a partial body plan is shown in Figure 3-1. The model tested is shown in Figure 3-2.

The Davidson Laboratory testing program included the following:

(a) Bench tests of the Flume tank at a roll amplitude of $\pm$ 2° over an assigned frequency range.

(b) Still water roll extinction tests at zero speed and 12.0 knots.

(c) Regular beam sea tests at zero speeds with varying wave lengths.

(d) Regular beam sea tests at zero speed with varying wave heights.

(e) Regular beam sea tests at varying speeds.

The results of these tests are summarized in Table 3-3. Figure 3-3 shows a plot of this data which amounts to roll response amplitude operators (RAO's) for the vessel with and without tanks. Since the model was not tested in irregular seas in order to measure the actual roll response spectra it

Table 3-2 Principal Characteristics of the Exploration Vessel RAYMOND M

Overall Length	165.00 feet
Breadth Moulded	38.00 feet
Test Displacement	1263.65 tons
Mean Draft	10.40 feet
Test GM	9.20 feet
Test KG	10.30 feet
Natural Rolling Period	5.65 seconds
Natural Rolling Frequency	1.26 rad/sec
Flume Tank Liquid Level	9.84 feet
Weight of Liquid in Stabilizer Tank (approx.)	173.23 long tons*
Weight of Stabilizer Liquid as Percentage of Test Displacement	13.7 %

* Salt Water

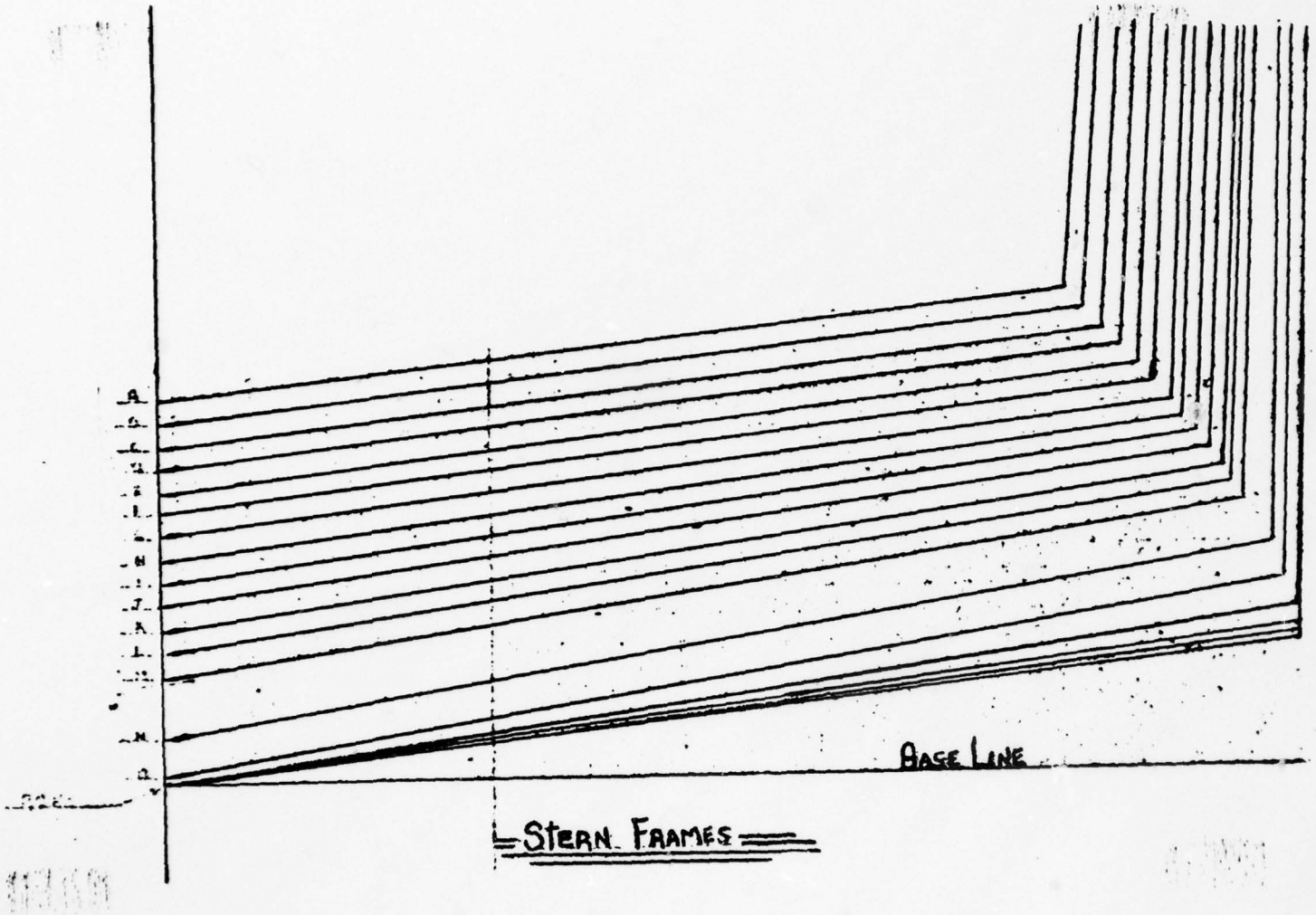


Figure 3-1 Partial Body Plan of the Exploration Vessel RAYMOND M

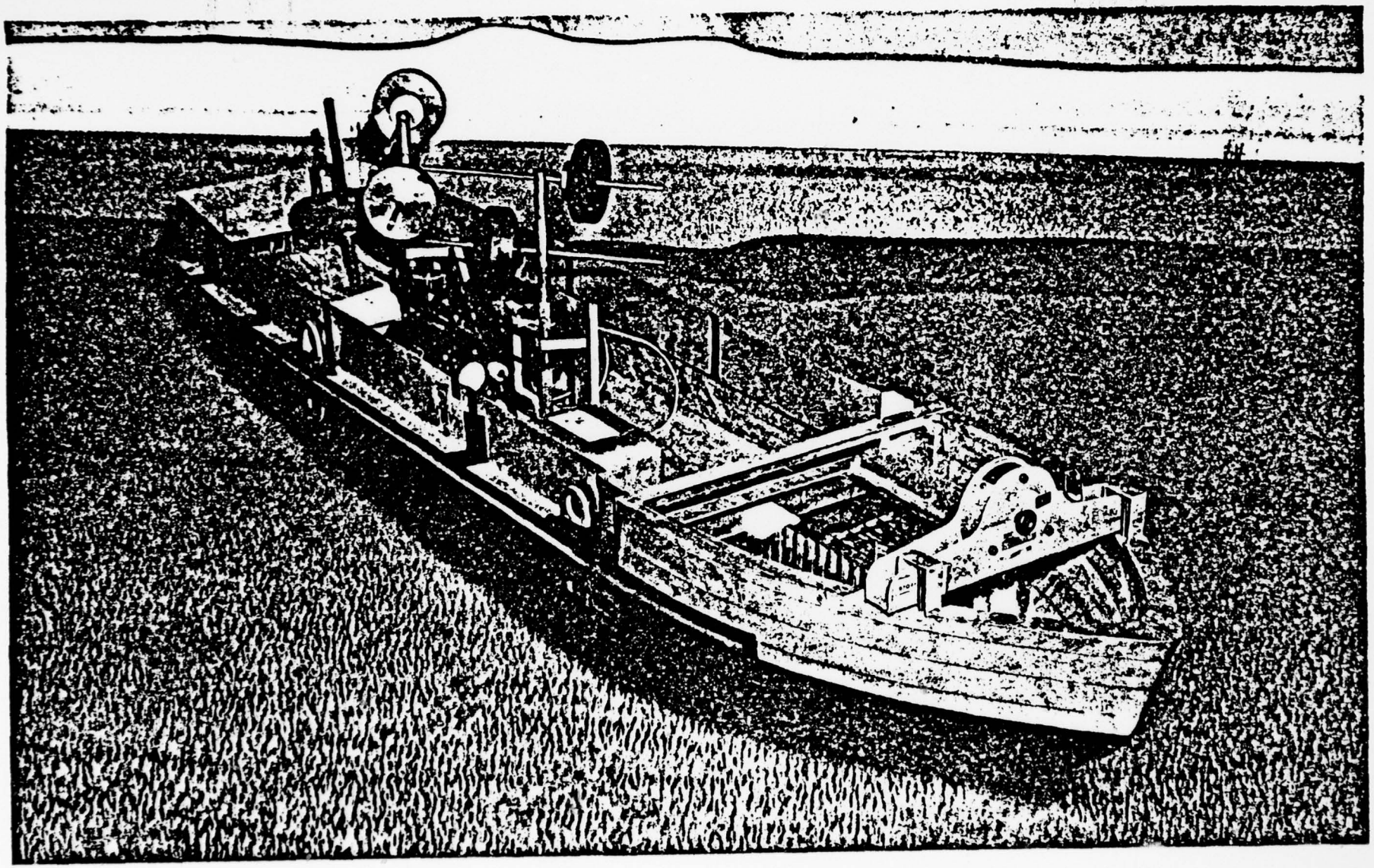


Figure 3-2 1/24 Scale Model of the Exploration Vessel RAYMOND M

Table 3-3 Results of the RAYMOND M Model Tests in Regular Waves

Fig. No.	Wave Condition (L_w x H_w)	Speed (Knots)	Stab. Roll (Degrees)	Unstab. Roll (Degrees)	% Red. of Model
8	163' x 1.2'	0	3.6	11.4	68.4
9	163' x 0.5'	0	1.2	6.4	81.3
9	163' x 1.5'	0	4.3	12.5	65.6
9	163' x 1.8'	0	5.4	13.4	59.7
10	163' x 1.2'	5	3.6	11.2	67.7
10	163' x 1.2'	10	3.3	10.0	67.0
10	163' x 1.2'	14	2.0	4.4	54.5

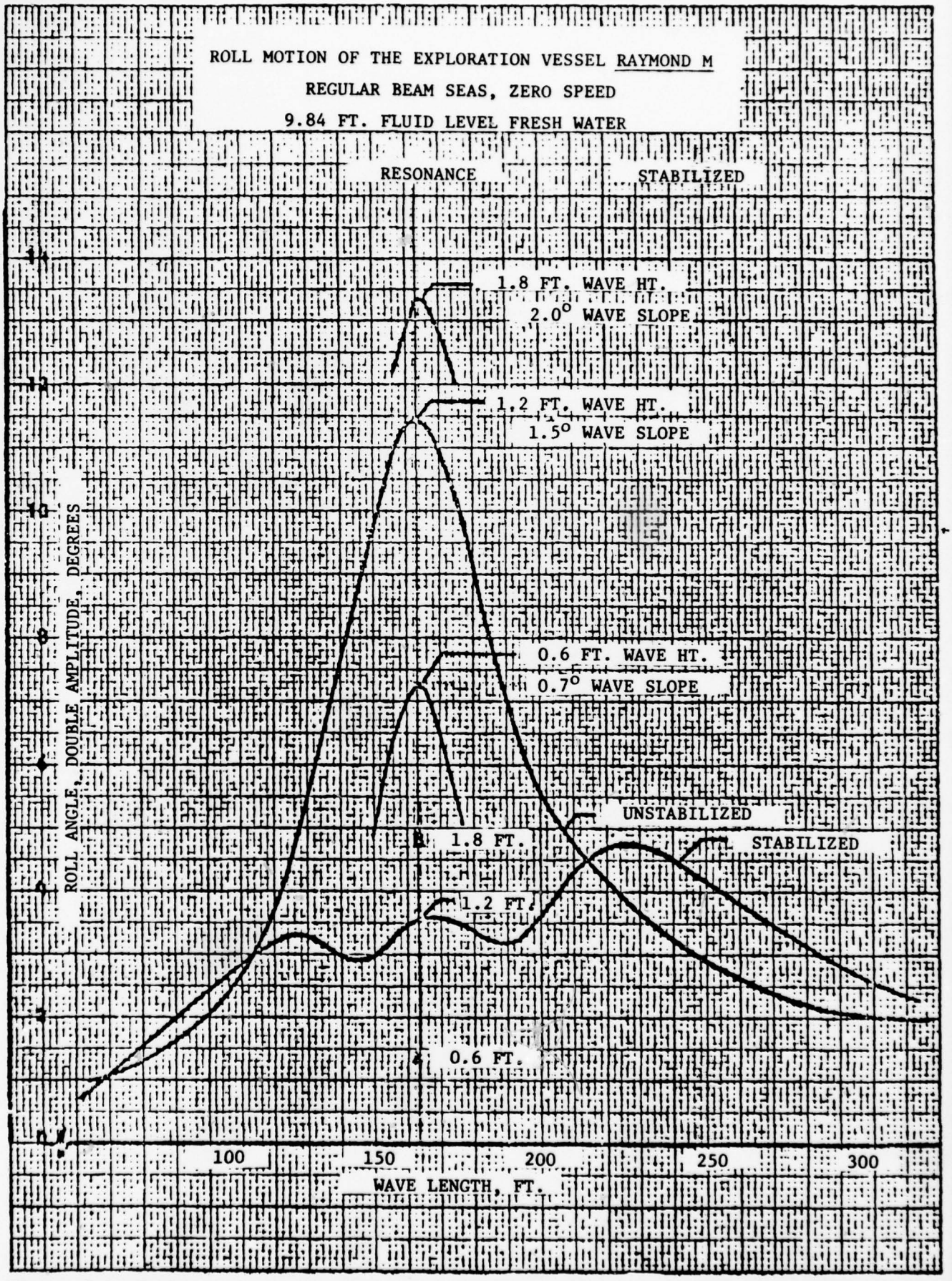


Figure 3-3 Stabilized and Unstabilized Roll Amplitude Operators for the RAYMOND M, beam seas, zero speed.

is impossible to draw any conclusions regarding the percentage roll reduction (rms, significant, etc.) to be expected in the actual vessel operation at sea. The percentages of roll reduction shown for each regular wave condition are not truly representative of what the ship will see in a real sea. However a letter sent by Mobil Oil Corporation, Geophysical Services, owners of the RAYMOND M to J. J. McMullen Associates expresses a clear indication of customer satisfaction with the system.

2. Model Test Results for the Offshore Supply Vessel IMPERIAL SERVICE (ref. 3).

The IMPERIAL SERVICE was one of four offshore supply vessels retrofitted with the FLUME system for Zapata Marine Service, Inc. in 1970. The installation of these tanks was prompted by the need to reduce heavy roll response of the Zapata vessels in order to maintain their supply schedule.

The IMPERIAL SERVICE has a moulded or rounded hu-l and so do the rest of the Zapata vessels equipped with tanks. Consequently the results of these tests do not answer the question of whether or not significant roll reduction will be achieved by installing passive anti-roll tanks in double chined offshore supply vessel hulls such as the T-AGOS. However, it is of interest to discuss these tests since reference is made to the roll response of moulded hulls as compared to single and double chined hulls.

A 1/15 scale model of the IMPERIAL SERVICE was tested in order to examine the response of the vessel to various sea conditions. Figure 3-4 is a profile of this vessel showing the tank arrangement as installed on the actual ship. Table 3-4 gives the principal characteristics. The following series of tests were conducted:

(a) Regular beam seas at varying wave length and at various wave heights at zero speed.

(b) Regular bow seas at three wave lengths, at various speeds with a wave height of 6 feet.

(c) Irregular head seas with an average period of 7.9 seconds and a significant wave height of 7.74 feet.

The roll response was determined by conducting tests in regular beam and bow seas. The results of the beam sea tests are shown in Figure 3-5 for the tank-stabilized and unstabilized model with and without bilge keels. In addition to the reduction in roll due to the tanks a significant roll reduction is achieved with the use of bilge keels. Figure 3-6 shows the roll response amplitude operator (roll angle/wave slope vs. frequency ratio) for the IMPERIAL SERVICE. Also, Figure 3-6 gives roll RAO's for vessels of similar size but with single and double chined hulls. The particulars of these chined vessels are given in Table 3-5. From Figure 3-6 it is obvious that chined vessels respond less in roll than rounded hulls. In fact, the McMullen report makes the following statement:

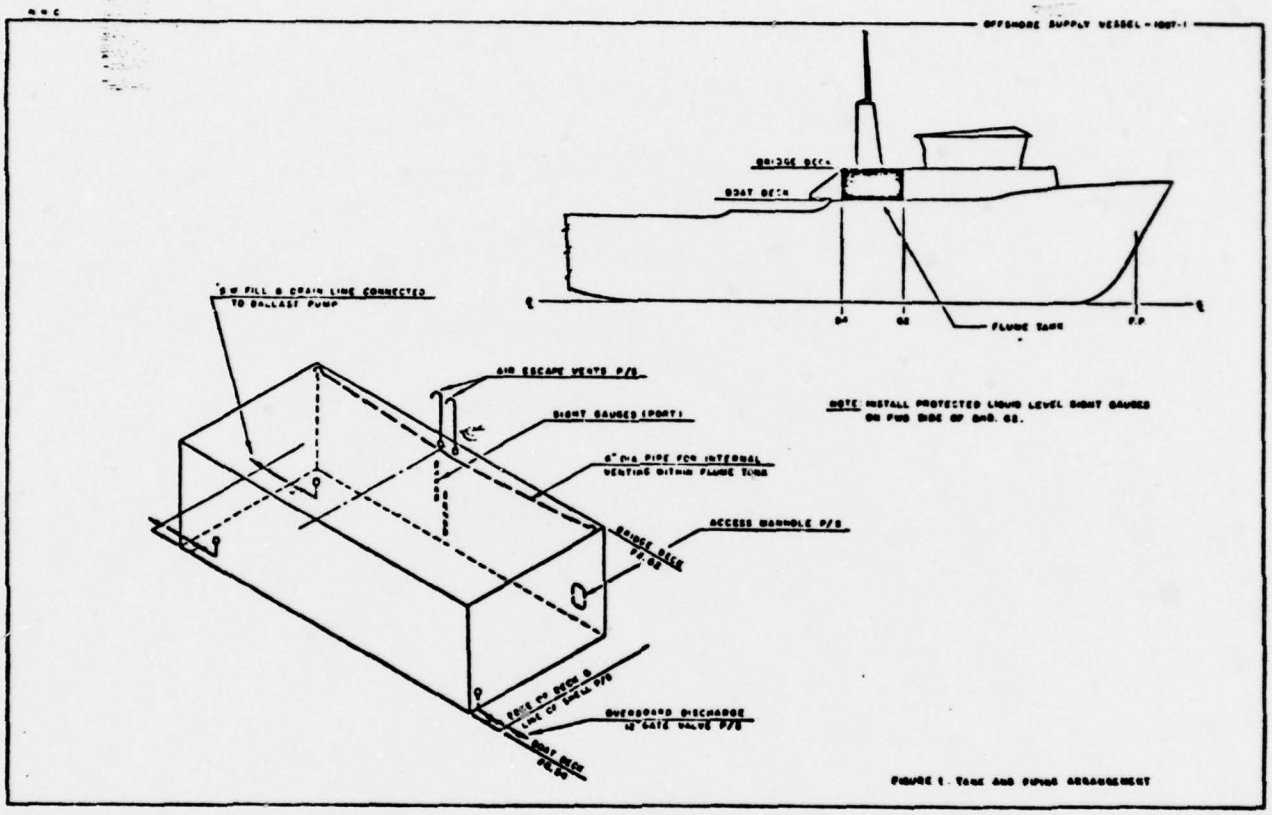


Figure 3-4 Passive Anti-Roll Tank Arrangement in the M/V IMPERIAL SERVICE

Table 3-4 Principal Characteristics of the M/V IMPERIAL SERVICE

	M/V IMPERIAL SERVICE
LBP (ft)	163.0
Beam (ft)	38.5
Depth (ft)	17.0
Displacement (lt)	1400 - 1800
Draft (ft)	15 (approx)
Metacentric Height (GM-ft)	4.5 - 6.5
Natural Roll Period (sec)	7.0
Bilge Keels	12" x 49'

Imperial Service Class Vessels

Model 4168^{Z} - JJM 1087-1

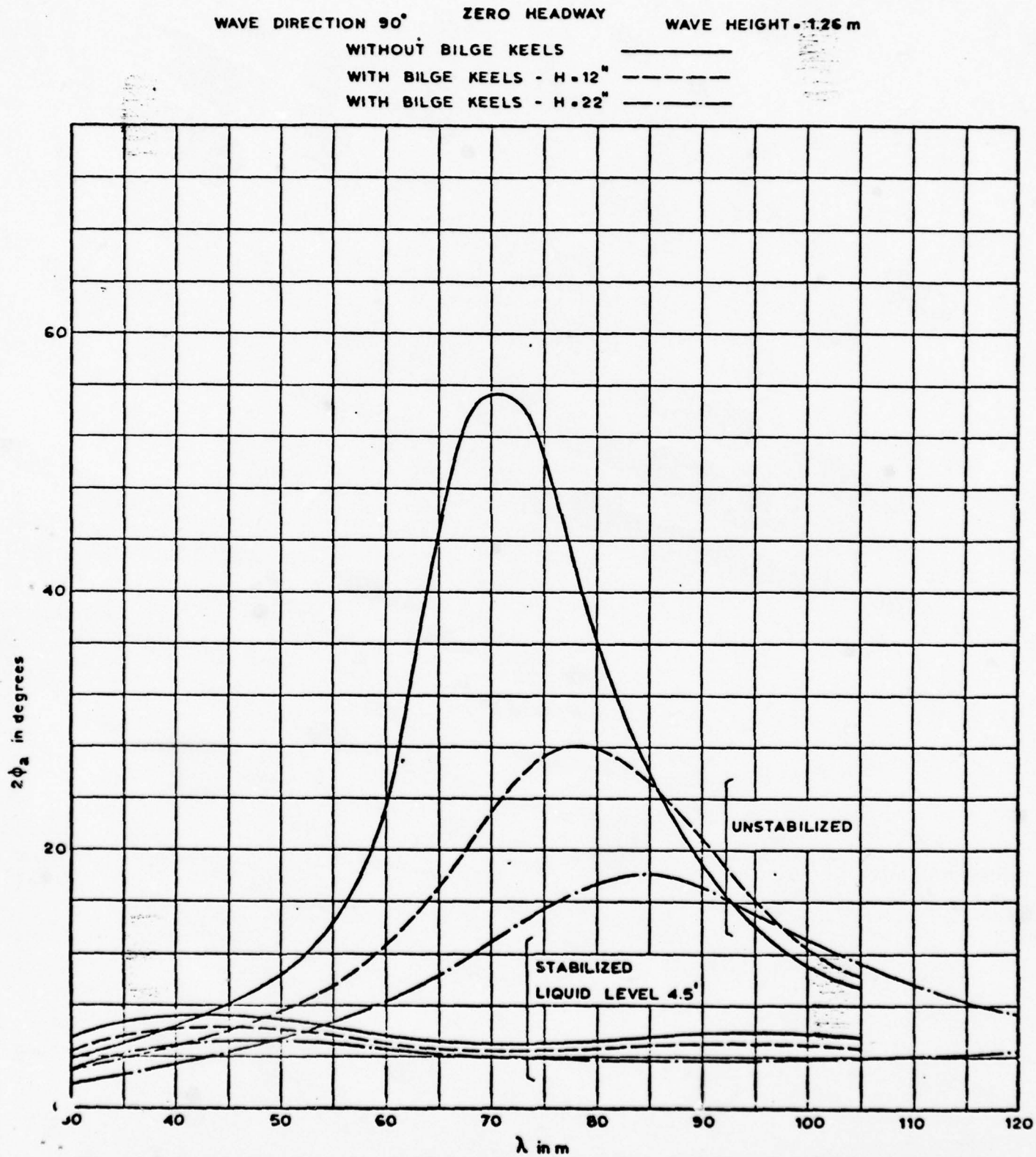


Figure 3-5 Regular Beam Sea Roll Response for a Tank-Stabilized and Unstabilized Model of the IMPERIAL SERVICE with and without Bilge Keels.

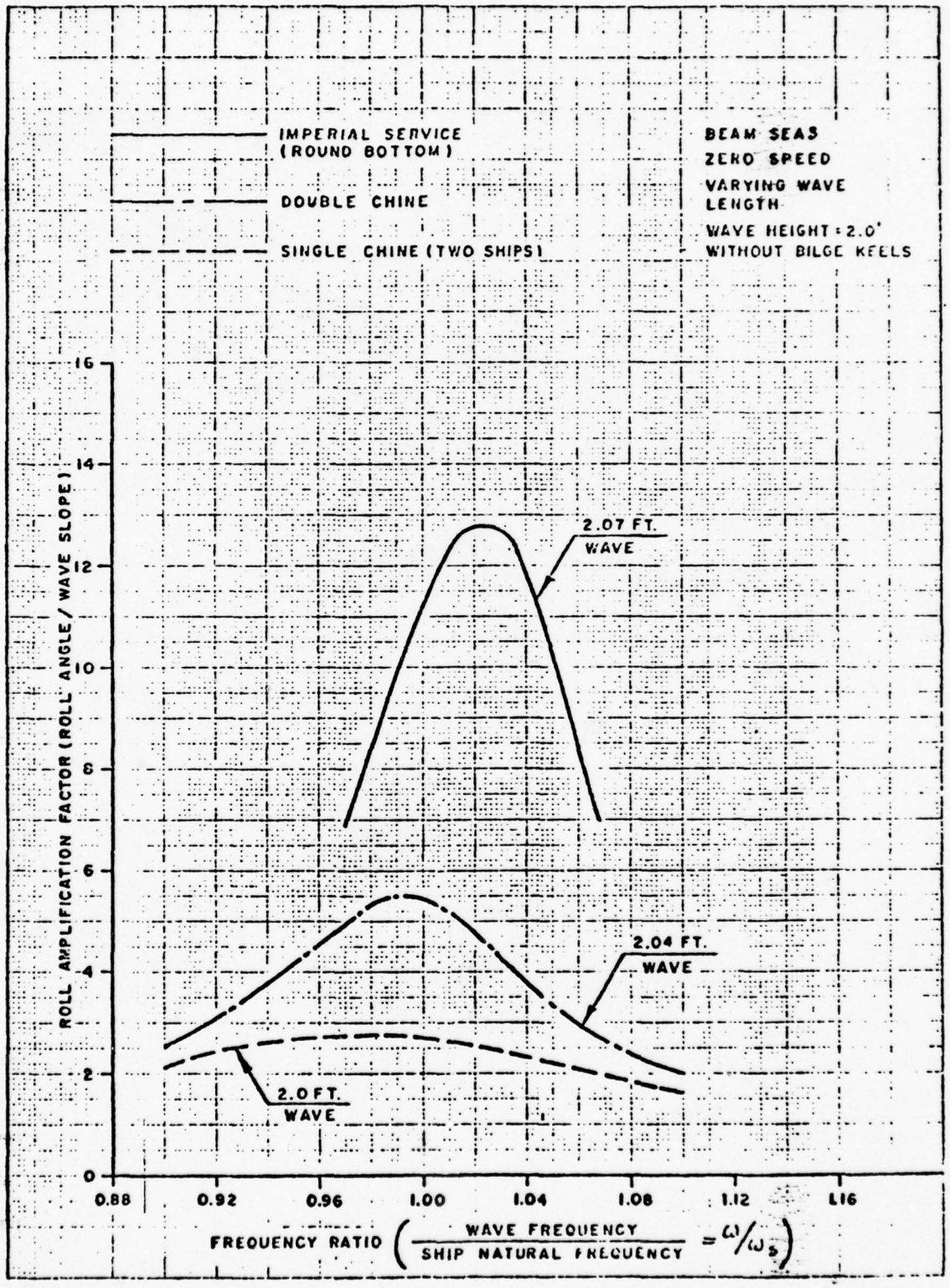


Figure 3-6 Comparison of Roll Response Amplitude Operators for Offshore Supply Vessels of Differing Hull Form

Table 3-5 Principal Characteristics of Chined Offshore Supply Vessels of Similar Size as the IMPERIAL SERVICE

Characteristic	Double Chine	Single Chine	Single Chine
Length Overall (feet)	165.0	165.0	165.0
Length Between Perpendiculars (feet)	160.0	160.0	160.0
Breadth, Moulded (feet)	36.0	38.0	38.0
Depth, Moulded (feet)	15.0	13.0	12.0
Test Displacement (long tons)	1008.0	1066.0	1264.0
Test GM (feet)	8.4	9.0	9.2
Natural Rolling Period (seconds)	5.00	5.50	5.65
Mean Draft at Test Displacement (feet)	9.5	9.14	10.4
Bilge Keels	None	None	None

". . . the rounder the hull the larger the roll response. The rounder hull has a response twice as high as a double chine hull and about four times that of the single chine hull. Therefore, for the round bottom hull in question, some form of stabilizing device, such as bilge keels or a stabilizing system should definitely be considered."

This statement seems to indicate that the decision to install anti-roll tanks on chined offshore supply vessel hulls would not be as clear and straight forward as in the case of a rounded hull.

Figure 3-7 shows the results of full scale tests conducted in 1971 onboard the IMPERIAL SERVICE. As expected, significant roll reduction is achieved with the tanks.

3. Other Flume Tank Installations

In addition to the two vessels discussed above, J. J. McMullen has installed passive anti-roll tanks in other offshore supply vessels of similar size to the T-AGOS. Examples of these are shown in Figure 3-8 which is an 8,000 HP ocean tug and in Figure 3-9 which is a 185 utility supply vessel. The latter is currently under construction at Mangone Shipyards in Houston, Texas, and is of the hard chine type. In both the tug and the utility vessel the tanks are installed aft and below deck.

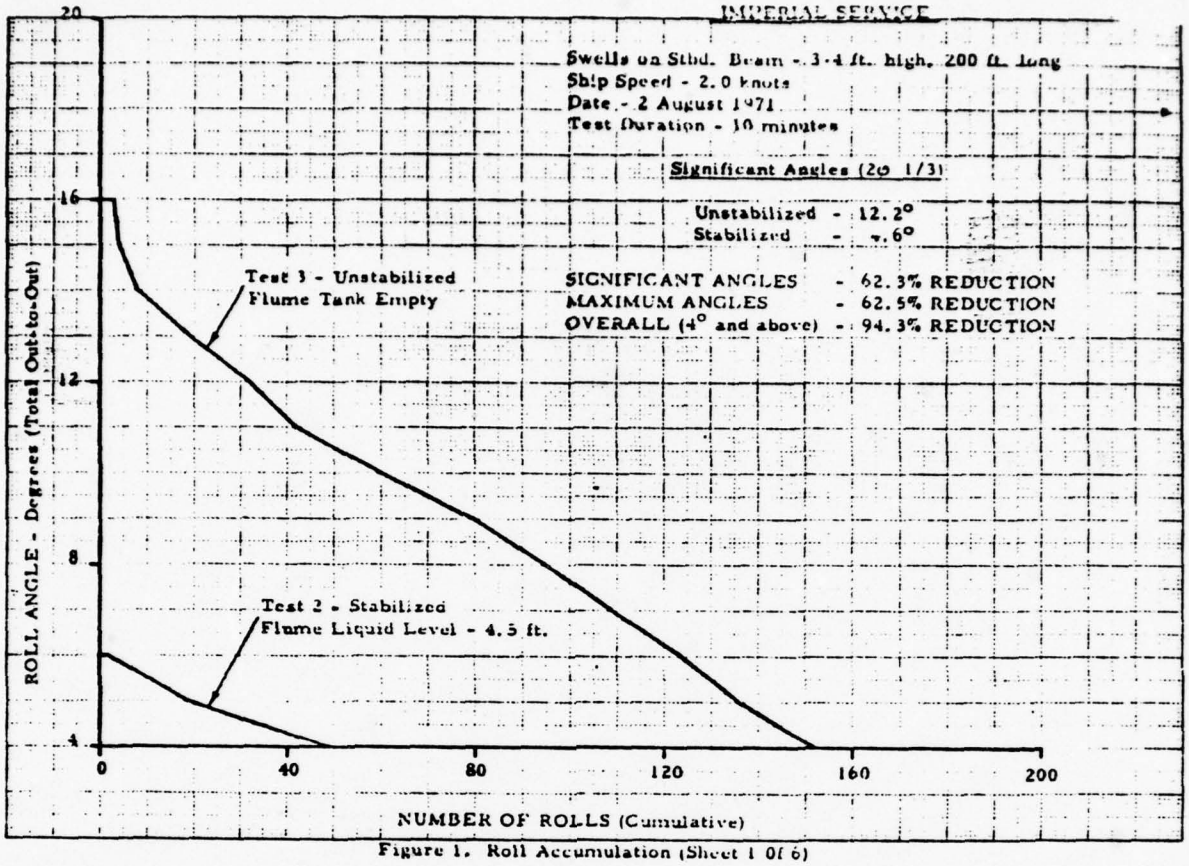
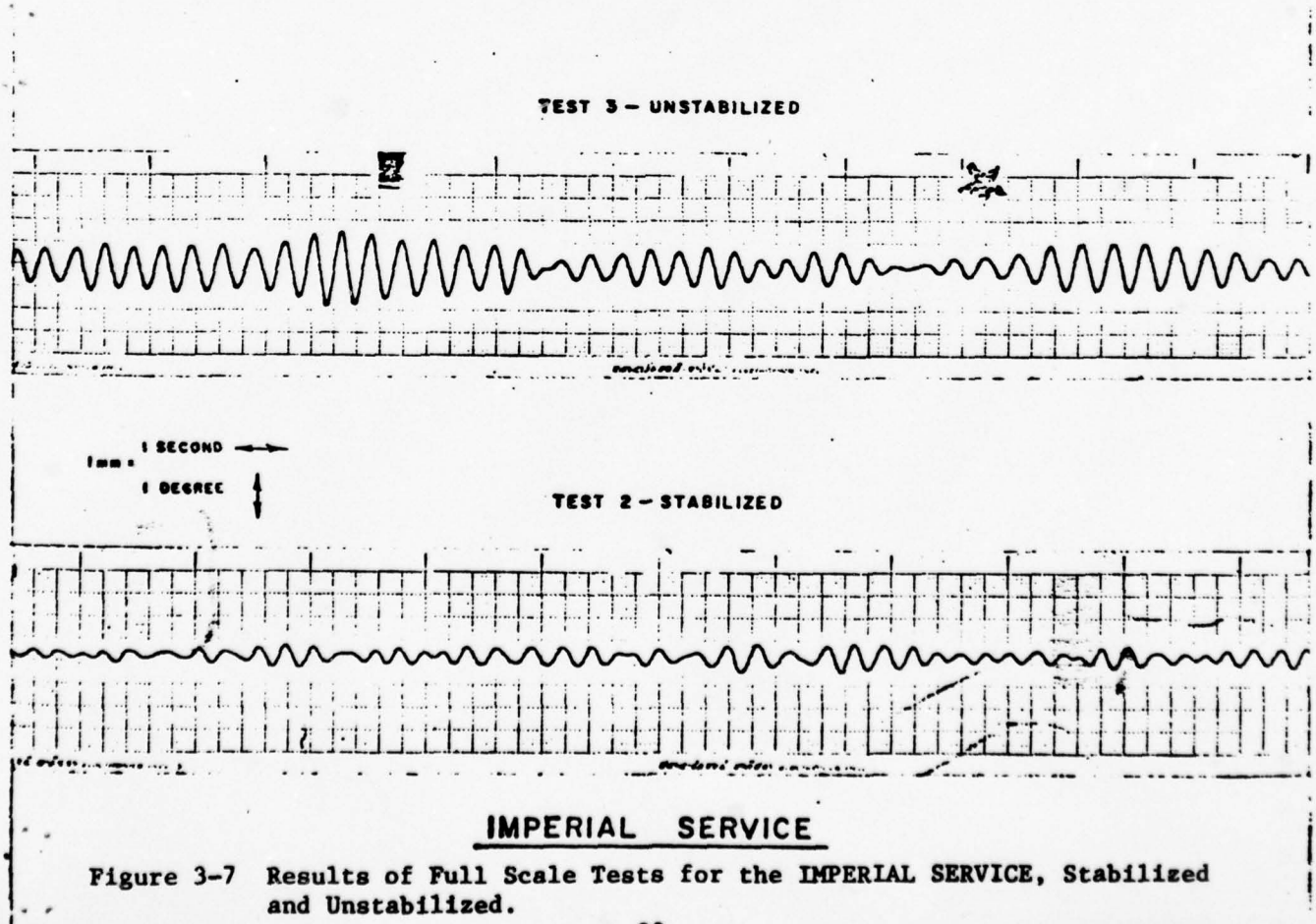


Figure 1. Roll Accumulation (Sheet 1 Of 6)



IMPERIAL SERVICE

Figure 3-7 Results of Full Scale Tests for the IMPERIAL SERVICE, Stabilized and Unstabilized.

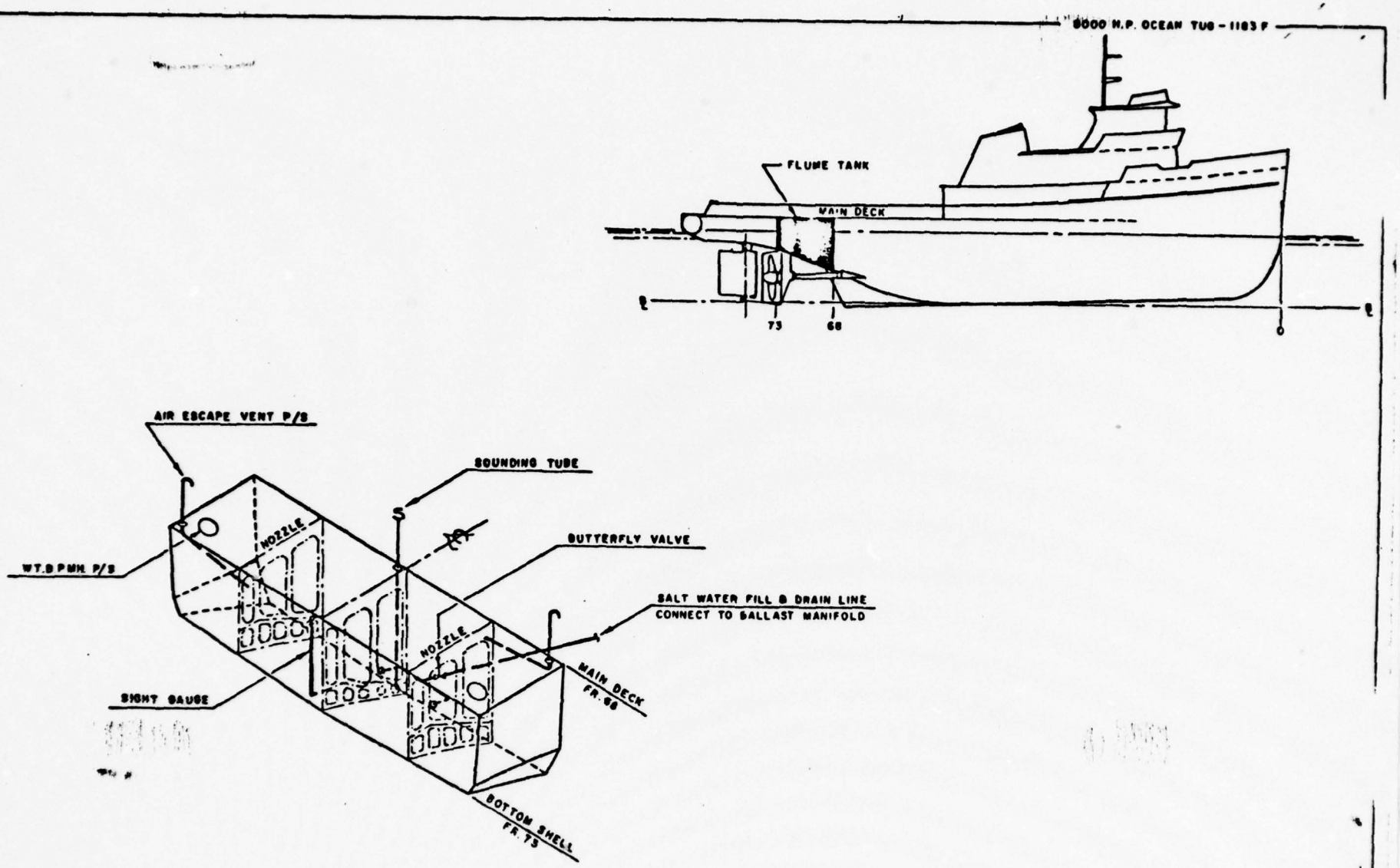


Figure 3-8 Passive Anti-Roll Tank Installation on an 8000 HP Ocean Tug

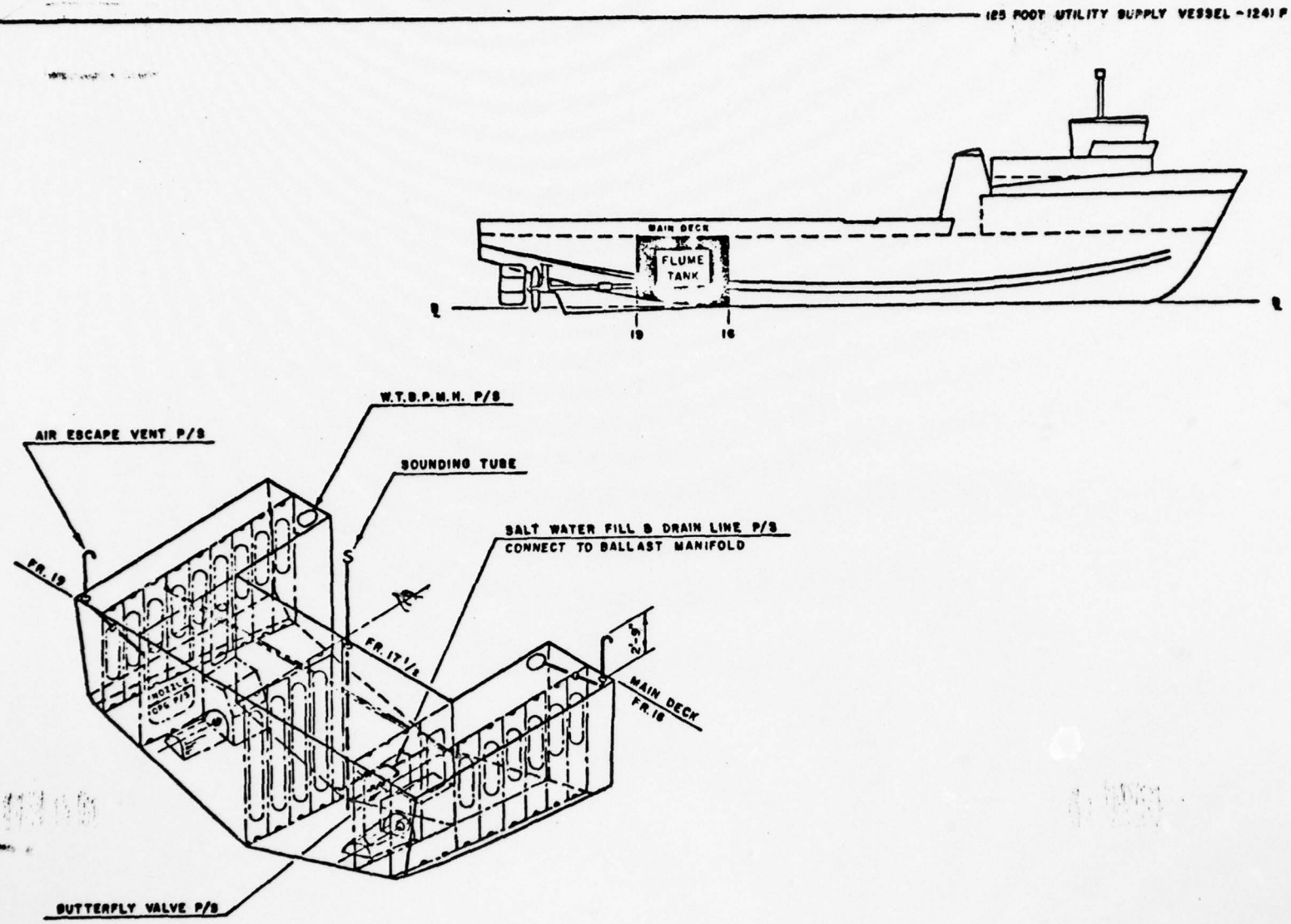


Figure 3-9 Passive Anti-Roll Tank Installation on a 185-foot Utility Supply Vessel

3.3 INPUTS FROM OFFSHORE SUPPLY VESSEL BUILDERS AND OPERATORS

In order to obtain information concerning the construction practices of builders and the experience of operators of offshore supply vessels a questionnaire was prepared and mailed to the companies listed in Table 3-6. A copy of the questionnaire is given in Appendix III.

Rather than waiting for the return of the completed questionnaires it was decided to expedite the survey by following up our mailing with telephone calls to some of the larger builders and operators in order to get their opinions concerning tank performance in their vessels. The following is a summary of these communications. In each case the telephone number of the representative contacted is given for future reference.

1. Zapata Marine Service, Inc. (713-226-6000).

   Contact was made with Mr. Thomas Ballantine, Vice President of Engineering and Maintenance responsible for the operation of Zapata's service fleet. Mr. Ballantine indicated that Zapata operates a fleet of approximately forty eight (48) offshore service vessels. These vessels include crew boats, tugs, supply boats and anchor handling tug-supply vessels. The majority of the fleet is made up of the latter type. Several of their vessels are equipped with passive, anti-roll stabilization tanks of the Flume design. These include the following:

   M/V MAJESTIC SERVICE

   M/V IMPERIAL SERVICE

Table 3-6 Builders and Operators of

Offshore Supply Vessels

Alexander Shipyards, Inc.	New Orleans, La.
American Marine Corp.	New Orleans, La.
Arthur Levy Boat Service	Morgan City, La.
Bethlehem Steel Corp. (Shipbuilding Division)	Beaumont, Texas
Big River Shipbuilding, Inc.	Vicksburg, Miss.
Blount Marine Corp.	Warren, R. I.
Bludworth Shipyard	Houston, Texas
Bollinger Machine Shop & Shipyard, Inc.	Lockport, La.
Breaux Baycraft, Inc.	Loreauville, La.
Brown Shipbuilding Co.	Houston, Texas
Burton Shipyard, Inc.	Port Arthur, Texas
Corpus Christie Marine Services, Inc.	Corpus Christie, Texas
Defoe Shipbuilding	Bay City, Michigan
Equitable Equipment Company	Madisonville, La.
Halter Marine Fabricators	Moss Point, Miss.
Halter Marine Services	Lockport, La.
Levingston Shipbuilding Co.	Orange, Texas
Mangone Shipbuilding Co.	Houston, Texas
Manitowoc Shipbuilding, Inc.	Manitowoc, Wisconsin
Marinette Marine	Marinette, Wisconsin
McDermott Shipyard	Morgan City, La.
Platzer Boat Works	Houston, Texas
Quality Equipment Co., Inc.	Houma, La.
Scully Bros. Boat Building	Morgan City, La.
South Texas Shipyard, Inc.	Corpus Christie, Texas
State Boat Corporation	Houston, Texas
Tidewater Marine	New Orleans, La.
Todd Shipyards Corp.	Houston, Texas
TRACOR Marine	Port Everglades, Florida
Zapata Marine Service, Inc.	Houston, Texas
Zigler Shipyards, Inc.	Mermentua, La., Jennings, La.

M/V PARAMOUNT SERVICE

M/V AMBASSADOR SERVICE

M/V SOVERIGN SERVICE

M/V STATESMAN SERVICE

M/V DOMINION SERVICE

M/V CONSTITUTION SERVICE

M/V INDEPENDENCE SERVICE

Campbell Industries Hull 118 (FREEDOM)

Campbell Industries Hull 119 (HERITAGE

Campbell Industries Hull 120 (LIBERTY)

Campbell Industries Hull 121 (PIONEER)

All of the above vessels have a moulded hull construction with bilge keels.

The following Zapata vessels have been built with a single chine type construction:

M/V VIKING SERVICE

M/V THOR SERVICE

M/V SAXON SERVICE

M/V SCANDIA SERVICE

M/V COLUMBIA SERVICE

M/V REPUBLIC SERVICE

M/V VICTORY SERVICE

M/V VALIANT SERVICE

M/V VENTURE SERVICE

M/V VIGILANT SERVICE

M/V HERCULEAN SERVICE

M/V SPARTAN SERVICE

These chined vessels do not have any type of stabilization system.

The remainder of the Zapata Marine fleet is made up of varying designs, the majority of which approach the chine type definition. Again, none of these vessels has any type of stabilization system installed.

In general, Zapata Marine's philosophy is that if they have a chine boat built they would not install a passive anti-roll stabilization tank. However, it was pointed out by Mr. James W. Gray, Senior Naval Architect of Zapata, that they would want to review and test a hard chine configuration if the overall length was 200 ft. or greater. Furthermore, any vessel of substantial size with a moulded hull would be constructed with some type of stabilization system. A copy of Mr. Ballantine's letter with the above comments is given in Appendix IV.

2. Tidewater Marine (504-822-1740)

Contact was made with Mr. Anthony Hattier, Naval Architect, who indicated that Tidewater has 385 vessels in service of which only 6 have Flume passive anti-rolling tanks. These vessels have a length of 218 ft. and a 40 ft. beam and were designed by Burness, Corlett and Partners, Ltd., of the United Kingdom. Two of the vessels were built by Tacoma Boat and four were built in Norway. These are:

M/V SUN

M/V MOON

M/V MAMOTH

M/V GOLIATH

M/V GIANT

M/V SUPREME

All six vessels have moulded hulls.

Mr. Hattier made the comment that Tidewater Marine's feeling is that their vessels do not need anti-rolling tanks to perform their services on schedule. Furthermore he indicated that the reason tanks were installed on the six vessels named above was simply due to the standard practice of the vessel designers. When asked for his opinion regarding operations in Sea State 4 by the T-AGOS his response was that, with a 40-ft beam vessel, tanks are not needed at all.

3. TRACOR Marine (305-463-1211).

Contact was made with Mr. R. Connolly who indicated that TRACOR has chartered twenty-five (25) vessels between 110 ft. and 190 ft. in length. Of these only one vessel, the STATE WAVE (120 ft. in length) owned by State Boat Corporation, is equipped with anti-rolling tanks. TRACOR has operated with no significant motions problems in bad areas such as the coast of Greenland on NAVAIR survey projects. Mr. Connolly's personal opinion is that roll stabilization for survey and geophysical operations can certainly help if cost is not a limitation. He indicated that passive anti-roll tanks are not worth the expense if they are to be retrofitted into an existing vessel. However, it is probably wise to install them if the vessel is to be built, subject of course to the availability of funds.

4. State Boat Corporation (713-528-5359)

Contact was made with Mr. Dave Miller, President of State Boat. He indicated that they operate one vessel retrofitted with a Flume tank. This is the STATE WAVE referred to by TRACOR. The vessel has a full (rounded) midship section with a partial hard chine and the tank is fitted in the cargo hold under the deck. The vessel is ten years old and has operated in a variety of locations including Alaska. State Boat is very pleased with the system and feels that the use of cubic has been justified.

He also indicated that they own several vessels fitted with "rolling chocks" (bilge keels) but do not care too much for them because of damage likelihood when alongside a drilling rig.

5. Arthur Levy Boat Service (504-385-0900)

Contact was made with Mr. Preston Thomas, Vice President for International Operations. He indicated that none of the Levy vessels are fitted with passive anti-rolling tanks. Levy has three offshore supply vessels of the low freeboard, low superstructure Gulf Coast type design operating in the North Sea with satisfactory results. Two of these, the BARENTS SEAHORSE and the CELTIC SEAHORSE are fitted with approximately 18-inch "rolling chocks" (bilge keels). When one of these vessels lost a bilge keel in service the difference in rolling characteristics was noticed immediately. Mr. Thomas indicated that bilge keels have provided satisfactory roll damping

and in his opinion the dedication of cubic to anti-rolling tanks would not be justified.

6. Star Offshore Services

This company was not contacted directly but information on their vessel STAR ARCTURUS was supplied by Mr. R. Buie of NAVSEA PMS 383A4. Mr. Buie indicated that the STAR ARCTURUS is equipped with a Flume anti-rolling tank and it operates in the North Sea. His comment was that he had been aboard the vessel while operating in the North Sea and that the performance of the tank was excellent. The STAR ARCTURUS has a moulded hull form. Appendix V gives the characteristics of this vessel.

7. Halter Marine (601-475-1211)

Contact was made with Mr. G. Cox who indicated that Halter has never installed passive anti-rolling tanks in any of the vessels built by them. All Halter vessels are single-chined through the mid body and double chined aft and forward. Mr. Cox stated that many operators have expressed to Halter that they do not feel the need for anti-rolling tanks with their offshore supply vessels.

8. Marinette Marine (715-735-9341)

Contact was made with Mr. James Derusha who indicated that Marinette is currently building four (4) ATF's with the same hull as the one presently considered for the T-AGOS. These ATF's are not fitted with anti-rolling tanks. Marinette built the 185-ft pilot vessel NEW YORK fitted with Flume tanks. The NEW YORK has a moulded hull and the owner has been very pleased with their performance.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Several conclusions can be drawn from the survey reported herein. These are:

1. No more than 5 to 10 percent of all offshore supply vessels built and owned by U. S. builders and operators have passive anti-rolling tanks.
2. With very few exceptions all offshore supply vessels equipped with passive anti-roll tanks are of the moulded or rounded hull type. Model test results and operational experience at sea clearly show that the roll response of moulded hull vessels is significantly larger than that of single and double chined ones.
3. Several operators feel that bilge keels ("rolling chocks") greatly improve the roll response characteristics of offshore supply vessels.
4. Several builders and operators feel that anti-rolling tanks are not needed in offshore supply vessels.
5. One boat operator suggests that for a vessel over 200 feet in length tests should be conducted prior to deciding whether or not tanks should be installed.
6. Several operators indicated that vessels with chined hulls operating in Alaska and the North Sea without anti-rolling tanks are conducting operations free of severe rolling.
7. All owners of offshore supply vessels (with moulded hulls) equipped with passive anti-rolling tanks are very pleased with their performance.
8. The results of towing tank tests of offshore supply vessel scale models with tanks in regular seas are inconclusive. Regular wave

tests fail to show the actual effect of the tanks in a real sea. Regular sea tests yield the roll response amplitude operators but say nothing about the roll response spectra of the vessel in a sea state. The need for looking at the total roll response spectra was clearly demonstrated in reference (1).

9. Based on the comments made by a major tank manufacturer and the builders and operators of offshore supply vessels it is evident that the significant roll angle reductions typically achieved with tanks installed in vessels with moulded hulls may not be achievable in the case of vessels with double and single chined hulls whose roll response is considerably less than that of the moulded hull types. Consequently, it would appear that a well-planned model test program in irregular seas should be conducted to determine the levels of roll reduction to be achieved by installing anti-rolling tanks on the T-AGOS. The size of the model should be sufficiently large to minimize scale effects. Furthermore, a scale model of the tank should be tested first on an oscillating table or equivalent apparatus to determine the natural frequency of the tank and its overall dynamic characteristics required to meet the design criteria.

5.0 BIBLIOGRAPHY ON ROLL STABILIZATION

As part of the effort devoted to this survey an extensive set of publications on the topic of roll stabilization was compiled. A partial bibliography has been included in Appendix VI for future reference.

REFERENCES

1. "Crew Comfort Design Study for the T-AGOS," NAVSEC REPORT 6136-77-13, Prepared by Giannotti & Buck Associates, Inc., April 1977.

2. "Investigation of Rolling Characteristics of Exploration Vessel RAYMOND M Equipped with the FLUME Stabilization System," Prepared by John J. McMullen Associates, Inc., for Mobil Oil Corporation, Report 917-1, December 1966.

3. Excerpts from a report by J. J. McMullen prepared for Zapata Marine Service, Inc. in 1970.

APPENDIX I

SUPPLY VESSELS AND

COMBINATION TUG/SUPPLY VESSELS

LISTED IN THE ABS RECORD

NAME	DIMENSIONS, ft (LWL x B x T)	OWNER
ACADIAN DEFENDER	152 x 38 x 13.5	Trans Union Leasing Co. Chicago, Illinois
ACADIAN FREEDOM	152 x 38 x 13.5	
ACADIAN LIBERTY	152 x 38 x 13.5	
ACADIAN PATRIOT	152 x 38 x 13.5	
ACADIAN VALOR	152 x 38 x 13.5	
ACADIAN VICTORY	152 x 38 x 13.5	
ADRI TIDE	164.16 x 38 x 15.88	Tidewater Colon, Inc.
ADVANCE II	180 x 33 x 14.49	Cape Fear Technical Institute Wilmington, N. C.
AGLOO	69.3 x 21.2 x 818	B&R Tug and Barge, Inc. Juneau, Alaska
ALASKA HUSKY	169.92 x 36 x 16	Foss Launch & Tug Co. Seattle, Washington
ALBACORE	72.8 x 23.9 x 12.1	Galaxie Marine, Inc. Morgan City, La.
ALLIANCE	111.75 x 25 x 12	Alliance Offshore Logistics, Inc.
GIBRALTAR	111.75 x 25 x 12	Hartford, Connecticut
AL RASHID	156.88 x 25.23 x 13.25	Sabik, Inc., New Orleans, La.
AMERICAN	125 x 32 x 10	American Vessels, Inc. Port Arthur, Texas
AMERICAN DELTA	153.5 x 38 x 13	American Delta Corp. Port Arthur, Texas
AMERICAN DELTA II	154.92 x 38 x 13	Scorpio Offshore, Inc. Port Arthur, Texas
AMERICAN DELTA III	154.92 x 38 x 13	American Galaxie, Inc. Port Arthur, Texas
AMERICAN ROBRAY III	153.5 x 38 x 13	American Offshore, Inc. Port Arthur, Texas
AMERICAN TIDE	156.17 x 36 x 12.47	Tidewater Mariners Morgan City, La.
ANCON	86 x 30 x 10.1	Fred Barefoot, New Orleans, La.
AQUAMARINE	161.68 x 38 x 15	Aqua Marine Assoc.
AQUAMARINE 501	164.25 x 40 x 15	Houston, Texas

NAME	DIMENSIONS, ft (LWL x B x T)	OWNER
ARAPAHO	120 x 24 x 10	Tidewater Venice, Inc. Morgan City, La.
ARCTIC MOON	157.8 x 38 x 12.6	Jackson Marine Corp. Corpus Christi, Texas
ARCTIC SEAHORSE	170 x 40 x 16.5	Levi, D. M., Inc. Morgan City, La.
ARCTIC SEAL	166 x 38 x 15	Seal Fleet, Inc. Galveston, Texas
ARCTIC TIDE	156.17 x 36 x 12.47	Tidewater Undertakings, Inc. Morgan City, La.
ARIEL	156.5 x 38 x 13	Ariel Rentals, Inc. Morgan City, La.
ATLANTIC SEAL	154.67 x 38 x 13	Seal Fleet, Inc. Galveston, Texas
ATLANTIC TIDE	156.7 x 36 x 12.47	Tidewater Industries, Inc. Morgan City, La.
AUREOLA	119 x 30 x 11.5	Black Cloud Boats, Inc. New Orleans, La.
AURIGA	149 x 34 x 11.5	Auriga, Inc., New Orleans, La.
AURORA	119 x 30 x 11.5	Slater Boat Service, Inc. New Orleans, La.
AUSTER	154.75 x 38 x 12	Auster, Inc., New Orleans, La.
AUTUMN TIDE	156.33 x 38 x 13	Tidewater Venice, Inc. Morgan City, La.
AVALON	76.8 x 22.5 x 11.4	Triangle Marine, Inc. Morgan City, La.
BAHIA SEAHORSE	90.16 x 24 x 10.5	Levi, Arthur Boat Service, Inc. Morgan City, La.
BALTIC SEAHORSE	166.92 x 38 x 13	United States Leasing Corp. Morgan City, La.
BARENTS SEAHORSE	170 x 40 x 16.5	Auries, Inc., Morgan City, La.
*BARTLET (Survey Vessel)	191.29 x 37.29 x 21.55	U. S. Navy

NAME	DIMENSIONS, ft (LWL x B x T)	OWNER
BAYOU TIDE	154.92 x 38 x 13	Tidewater Resources, Inc. Morgan City, La.
BAY SEAHORSE	102.75 x 25 x 12	United States Trust Co. of New York as Trustee (ALBSI) New York, New York
BEAUREGARD	141.83 x 35 x 12	Tidewater Grand Isle, Inc. Morgan City, La.
BENGAL SEAHORSE	155 x 38 x 13	Levi, Arthur Boat Service, Inc. Morgan City, La.
BERING EXPLORER	113.5 x 32 x 8.5	Anderson, Jack C., Jr. Juneau, Alaska
BERING SEAHORSE	176 x 38 x 13	Levy, D. M., Inc. Morgan City, La.
BIENVILLE	141 x 33 x 10.33	Tidewater Grand Isle, Inc. Morgan City, La.
BIG JIM (Iron)	98.3 x 28 x 12	F. B. Walker & Sons, Inc. Beloxi, Miss.
BIG ORANGE V	163.67 x 38 x 13	Zodiac Offshore, Inc. Wilmington, Del.
BIG RED TOO	91.4 x 22 x 9.4	Land and Marine Appl., Inc. New Orleans, La.
BLACK CREEK	82.8 x 22.1 x 8.4	Western Geophysical Co. of America, Biloxi, Miss.
BLUE FIN	157.33 x 36 x 12.5	Garber Bros., Inc. Morgan City, La.
BLUE MARLIN	140.17 x 34 x 11.5	Aquamarine Service, Inc. Morgan City, La.
BLUE WATER NO. 2 (Drilling Rig)	204.67 x 204.67 x 83.82	Santa Fe Marine, Inc. Wilmington, Del.
BOLD VENTURE	94.32 x 24 x 10.96	Zodiac Offshore, Inc. Port Arthur, Texas
BO-TRUC NO. 8	77 x 33 x 10.2	Cheramie Botruck #8, Inc. New Orleans, La.
BRICK TIDE	156.17 x 36 x 12.47	Tidewater Keels, Inc. Morgan City, La.

NAME	DIMENSIONS, ft (LWL x B x T)	OWNER
BURCH TIDE II	165.25 x 38 x 14	Tidewater Navigators, Inc. New Orleans, La.
CACHALOT (Wood)	76.1 x 24 x 5.3	McAlliston Equipment Leasing Co. Bellingham, Washington
CAIOBA SEAHORSE	166.92 x 38 x 13	Aurora Bora, Inc. Morgan City, La.
CALCASIEU	120 x 30 x 8	Tidewater California, Inc. Morgan City, La.
CALDWELL	151 x 35 x 12	Tidewater Grand Isle
CLAIBORNE	126.75 x 32 x 10	Morgan City, La.
CAPT KIDD	170 x 40 x 17	Slater Enterprises, Inc.
CALICO JACK	170 x 40 x 17	New Orleans, La.
CAPT FRANCOIS LE CERC	170 x 40 x 17	
CALLIOPE	124.7 x 24.4 x 11.3	Hahn, David Arthur Milwaukee, Wisconsin
CAMERON	116 x 30 x 8	Sea Tenders, Inc. Morgan City. La.
CANADIAN OLYMPIC	116.17 x 32 x 9	Petroleum Services Division Houston, Texas
CANARY ISLAND	170.15 x 38 x 15	Offshore Island Boats, Inc. Morgan City, La.
CAPRICORN	155.08 x 38 x 14	Zodiac Offshore, Inc. Wilmington, Del.
CARIBBEAN SEAL	154.75 x 38 x 12	Caribe Co. Galveston, Texas
CARIBE TIDE	146.17 x 36 x 12.47	Tidewater Transports, Inc. Morgan City, La.
CARL TIDE II	148.58 x 36 x 12	Tidewater Boats, Inc. New Orleans, La.
CAROL ANN	85 x 22 x 11.5	Deepwater Boats, Inc. Lake Chavlis, La.
CAYMAN ISLAND	170.15 x 38 x 15	Offshore Island Boats, Inc. Morgan City, La.
CEDAR CREEK	82.55 x 22 x 10.5	Western Geophysical Co. of America, Billoxi, Miss.

NAME	DIMENSIONS, ft (LWL x B x T)	OWNER
CELTIC SEAHORSE	170 x 40 x 16.5	Aura, Inc., Morgan City, La.
CENTURY	171.29 x 40 x 16	American Century Vessels, Inc. Houston, Texas
C. E. TIDE II	165.5 x 38 x 14	Tidewater Navigators, Inc. Morgan City, La.
C. G. G. NO. 15	220 x 80 x 14	John W. Mecom Glaveston, Texas
CHALLENGE	170 x 38 x 15	Challenge Rentals, Inc. Morgan City, La.
CHAMPION	170 x 38 x 15	Champion Rentals, Inc. Morgan City, La.
CHARLEEN B. (Iron)	91.7 x 24 x 7.9	Gerald P. Begnaud Corpus Christi, Texas
*CHAUVENET (Survey Vessel)	357 x 54 x 31	U. S. Navy
CHERAMIE BO TRUC 21	166.75 x 38 x 13.5	George Engine Co. New Orleans, La.
CHERAMIE BOTRUC NO. 7	95.17 x 36 x 10.33	Cheramie Bo Truc #7, Inc. New Orleans, La.
CHERAMIE BO TRUC NO. 11	142.5 x 36 x 12	Cheramie Bo Truc #11, Inc. New Orleans, La.
CHERAMIE BO-TRUC NO. 13	142.5 x 36 x 12	Cheramie Bros. Boat Co., Inc. New Orleans, La.
CHERAMIE BO-TRUC NO. 14	157.58 x 36 x 12	Cheramie Bo Truc No. 14, Inc. New Orleans, La.
CHERAMIE BO-TRUC NO. 15	142.5 x 36 x 12	Cheramie Bo Truc No. 15, Inc. New Orleans, La.
CHERAMIE BO-TRUC NO. 16	157.58 x 36 x 12	Cheramie Bo-Truc No. 16, Inc. New Orleans, La.
CHERAMIE BOTRUC NO. 17	167.25 x 38 x 13.5	Cheramie Bo Truc No. 17, Inc. New Orleans, La.
CHERAMIE BO TRUC NO. 18	167.33 x 38 x 13.58	Cheramie Bo Truc 18 Inc. New Orleans, La.
CHERAMIE BOTRUC NO. 19	167.33 x 38 x 13.58	Cheramie Bros Boat Co., Inc. New Orleans, La.

NAME	DIMENSIONS, ft. (LWL x B x T)	OWNER
CHERAMIE BOTRUC NO. 20	167.33 x 38 x 13.58	Cheramie Bros. Boat Co., Inc. New Orleans, La.
CHEVALIER DE GRAMONT	170 x 40 x 17	Slater Enterprises, Inc. New Orleans, La.
CHEVRON	88.8 x 20 x 10	Chevron Oil Co. Houston, Texas
CHRIS ZEPPA	180 x 120 x 8	Southern Shipbuilding Corp. New Orleans, La.
CIMARRON	154.92 x 38 x 12	Trinity Boat Co. Galveston, Texas
CLEO STATER	164.79 x 38 x 13	Levy, Arthur Co., Inc. Morgan City, La.
COASTAL CARRIER COASTAL CRUISER	140.17 x 34 x 11.5 155 x 38 x 13	Coastal Carriers, Inc. New Orleans, La.
COLORADO	106.32 x 24 x 10	Colorado Boat Company Galveston, Texas
COLUMBIA	156.67 x 40 x 15	Columbia Rentals, Inc. Morgan City, La.
COMANCHE	78 x 21.5 x 12	Tulsa Trawlers, Inc. Biloxi, Mass.
COMET DEFENDER	156.5 x 39 x 15 178.5 x 40 x 18.5	Hartford Ntl. Bank & Trust Co. Hartford. Connecticut
CONCORDIA	136.08 x 35 x 11.27	Global Marine, Inc. Galveston, Texas
CONSTELLATION	158 x 40 x 15	Constellation Rentals, Inc. Morgan City, La.
CONSTELLATION	160.75 x 38 x 14	American Constellation Corp. Port Arthur, Texas
CONSTRUCT TIDE	180 x 56 x 14.5	Tidewater Ventures, Inc. Morgan City, La.
CORAL SEAHORSE	176 x 38 x 13	Smith, Frank B. Trustee Morgan City, La.
CORAL SEAL	155 x 38 x 13	Moody, Robert L. Trustee Galveston, Texas

NAME	DIMENSIONS, ft. (LWL x B x T)	OWNER
COZUMEL ISLAND	170.15 x 38 x 15	Offshore Island Boats Morgan City, La.
CREOLE SUE	85 x 22 x 9.5	Creole Sue, Inc. Biloxi, Miss.
CSI I	72.4 x 26 x 6.1	D. H. & D. Ironworks, Inc. Houma, La.
C-TRUC	80.4 x 24.4 x 10.6	C-Truc, Inc. New Orleans, La.
DABNEY E. PETTY	154.33 x 38 x 12	Petty Geophysical Engineering Co. Corpus Christi, Texas
DANTZLER ASH	112.33 x 28 x 10.5	Mentor Offshore Boat Service New Orleans, La.
DANTZLER OCEAN SPRINGS	119 x 30 x 11.5	Atlas Offshore Boat Service Pascagoula, Miss.
DELTA CHROMALLOY NO. 3	140.67 x 36 x 15	Delta Mud & Chemical Co. Houma, La.
DELTA CORROSION II	82.8 x 20.2 x 9.5	Delta Corrosion Service New Orleans, La.
DEUTSCH TIDE	165.5 x 38 x 14	Tidewater Masters, Inc. Morgan City, La.
DILIGENTE	155.13 x 38 x 13	Offshore General, Inc. Morgan City, La.
DINO-C DIONNE-C JULIEN C	95.04 x 25 x 11.75 85.5 x 22.5 x 10 82 x 22 x 11.9	E. & G. Chouest Marine Service Houma, La.
DIXIE DANDY	71.3 x 21.7 x 11.2	Offshore Gulf Fisheries Morgan City, La.
DOLORES CHOVEST	154.58 x 38 x 12	3-C Tug Rentals Hauma, La.
DYNAMIC TIDE	154.17 x 38 x 12	Tidewater Ports New Orleans, La.
EAGLE	154.58 x 38 x 12	Eagle Rentals Morgan City, La.
EBB TIDE II FLOOD TIDE II	165.5 x 38 x 14 165.5 x 38 x 14	Tidewater Barges New Orleans, La.

NAME	DIMENSIONS, ft. (LWL x B x T)	OWNER
E. D. SMITH	98 x 23.67 x 10.5	Mobil Oil Corp. Morgan City, La.
EDWINA MARTIN	165.42 x 38 x 14	Tiger Services New Orleans, La.
ENDEAVOR	154.58 x 38 x 12	Endeavor Rentals Morgan City, La.
ENTERPRISE	178.67 x 40 x 18.5	Hartford, Ntl. Bank & Trust Hartford, Connecticut
EUNICE B	84.6 x 24.2 x 11.2	Barras Offshore Rentals Morgan City, La.
EVELYN TIDE	165.5 x 38 x 14	Tidewater Lines Morgan City, La.
FALCON (Alum.)	85.7 x 21.6 x 10.6	Crowley Maritime Corp. Coos Bay, Oregon
FALCON	140.5 x 34 x 10.5	Falcon Rentals Morgan City, La.
FLYING DIAMOND 1	138.17 x 36 x 15	Dowell Division of the Dow
FLYING DIAMOND 2	138.17 x 36 x 15	Chemical Co., New Orleans, La.
FRED H. MOORE	154.33 x 38 x 12	Mobil Marine Transport New York, New York
FRED NEWMANN	140.67 x 36 x 15	Intracoastal Drilling Houma, La.
GEMINI	141.17 x 36 x 12.5	Astro-Marine Inc. Houston, Texas
GEM TIDE	154.92 x 38 x 13	Tidewater Ships, Inc. Morgan City, La.
GOLDRILL 4	198.25 x 34 x 11.25	Golden Lane Drilling Co. Houston, Texas
GRADY FAGAN	165.5 x 38 x 14	Fagan Boat Service Cutoff, La.
GREAT REPUBLIC	183.25 x 38 x 16	Great Republic Rentals Morgan City, La.
GREAT TIDE	154.17 x 38 x 12	Tidewater Resources New Orleans, La.

NAME	DIMENSIONS, ft. (LWL x B x T)	OWNER
GUARICEMA	176 x 38 x 12.5	United States Trust Co. New York, New York
GULF FLEET NO. 1	155.13 x 38 x 13	Abdon Martin New Orleans, La.
GULF FLEET NO. 3	166.33 x 38 x 13	Gulf Mississippi Marine Corp.
GULF FLEET NO. 4	166.33 x 38 x 13	New Orleans, La.
GULF FLEET NO. 6	165.58 x 38 x 14	"
GULF FLEET NO. 8	167.04 x 38 x 15	"
GULF FLEET NO. 9	167.04 x 38 x 15	"
GULF FLEET NO. 10	165.42 x 38 x 14	"
GULF MARINER	121.75 x 32 x 12	Tug Leasing Corp. New London, Connecticut
GULF SEAL	154.58 x 38 x 12	Three R. Trust
INDIAN SEAL	185.42 x 40 x 17	Galveston, Texas
GULF SERVICE (Wood)	113.5 x 32 x 13.88	Sea Service, Inc. Houston, Texas
GUS TIDE	166.08 x 38 x 14	Tidewater Services New Orleans, La.
HALE TIDE	165.5 x 38 x 14	Tidewater Keels New Orleans, La.
HALIBURTON 202	105.7 x 31.8 x 5.4	Haliburton Co.
HALIBURTON 203	105.7 x 31.8 x 5.4	New Orleans, La.
HALIBURTON 218	165.5 x 38 x 14	
HEAVY TIDE	156.17 x 36 x 12.47	Tidewater Fleets Morgan City, La.
HERON	150 x 34 x 20	A. B. Church, Seattle, Wash.
HIGH TIDE II	165.25 x 38 x 14	Tidewater Navigators
HILL TIDE II	165.25 x 38 x 14	Morgan City, La.
HOGUE TIDE	166.08 x 38 x 14	Tidewater Undertakings New Orleans, La.
HOPE TIDE	165.5 x 38 x 14	Tidewater Keels, New Orleans, La.
HUGE TIDE	154.17 x 38 x 12	Tidewater Transit, New Orleans, La.
JACKSON	134.25 x 32 x 10	Bestwater Equipment Service Morgan City, La.
JEP TIDE	148.13 x 36 x 12	Tidewater Operations Morgan City, La.

NAME	DIMENSIONS, ft. (LWL x B x T)	OWNER
JEWEL TIDE KING TIDE	165.5 x 38 x 14 157.25 x 36 x 12.5	Venice Boat Corp. New Orleans, La.
J. H. LEVY	165.17 x 36 x 12.47	Levy, Arthur Marine Service Morgan City, La.
JOHN MORGAN	111.5 x 38.42 x 10.08	John Morgan Rentals Morgan City, La.
JOHN T. DAVIS	79.6 x 22 x 8	Walter Marine, Inc. Baton Rouge, La.
JUBAL EARLY	101.04 x 24 x 11.42	Jubal Early Rentals Morgan City, La.
JULAINE	200 x 54 x 11.6	Armco Steel Corp. New Orleans, La.
JUPITER	141.17 x 36 x 12.5	Astro-Marine, Inc. Houston, Texas
KANA KEOKI	156 x 36 x 14	ICB Leasing Co., New Orleans, La.
KERMAC VIII	102.4 x 32.3 x 5.1	Kerr-McGee Corp. Morgan City, La.
KERMAC WORKBOAT II	124 x 34 x 12	Transworld Drilling Co. Morgan City, La.
KERMAC WORKBOAT V	146.16 x 36 x 12.47	Kerr-McGee Corp. Morgan City, La.
KIRBY SMITH	101.04 x 24 x 11.42	Offshore Logistics Services Morgan City, La.
KYLE TIDE	129.5 x 32 x 9.5	Tidewater Lines New Orleans, La.
L. A. LEVY	142.33 x 35 x 12	Levy, L. A. Inc. Morgan City, La.
LAMCO SUPPLIER	138.5 x 36 x 15	Louisiana Mud Co., Inc. Houma, La.
LES LEVY	156.5 x 36 x 12.47	Kim, Inc., Morgan City, La.
LIGHTNING	156.5 x 29 x 15	Hartford Ntl. Bank and Trust Hartford, Connecticut
LIVINGSTON	136.08 x 35 x 11.27	Inca, Inc., Morgan City, La.

NAME	DIMENSIONS, ft. (LWL x B x T)	OWNER
LONG TIDE	148.58 x 36 x 12	Tidewater Navigators New Orleans, La.
LOUISIANA	144.92 x 35 x 11.5	Continental Boat Corp. Morgan City, La.
LOWELL STANLEY	166 x 38 x 13	United States Leasing Corp. Morgan City, La.
LOW TIDE	130 x 36 x 10.17	Tidewater Agencies, Inc. New Orleans, La.
RED RIVER	150 x 36 x 12.5	Tidewater Cameron, Inc.
MADISON	148 x 36 x 12	Morgan City, La.
ALLEN	141.83 x 35 x 12	"
FRANKLIN	153.58 x 35 x 12	"
MAGCOBAR MERCURY	134 x 36 x 12	Dresser Industries
MAGCOBAR METEOR	125 x 34 x 12	Houston, Texas
MAGCOBAR SATELLITE	125 x 34 x 12	"
E. R. LEVY	146.17 x 36 x 12.47	Levy, Arthur Cargo Boats, Inc.
MORGAN CITY SEAHORSE	166 x 38 x 13	Morgan City, La.
M. A. LEVY	157 x 36 x 12.5	"
M. L. LEVY	136.5 x 36 x 10	"
M. S. LEVY	142 x 35 x 12	"
MASTADON	168 x 38 x 10	Denrod Drilling Company
RHINO	182.8 x 40 x 17.33	Morgan City, La.
CARBOU	154.92 x 38 x 13	"
ELAND	154.92 x 38 x 13	"
MASTADON	169.9 x 38 x 16	"
ELK	154.92 x 38 x 13	"
GEMSBOK	165 x 38 x 13	"
HIPPO	182.8 x 40 x 17.33	"
LION	104.8 x 20.5 x 8.9	"
MEDITERRANEAN SEAL	154.75 x 38 x 12	Corpus Co., Galveston, Texas
MIDNIGHT COAST	166.33 x 38 x 13	Guzetta Offshore Marine Service,
MIDNIGHT WORKER	164.79 x 38 x 13	Inc. Port Arthur, Texas
MIGHTY RED	95 x 22.7 x 1.1	Land & Marine Applications, Inc.
MR. RED TOO	110 x 22 x 9.5	New Orleans, La.
MITRA TIDE	95 x 25 x 12.17	Tidewater Marine Corp. New Orleans, La.
MUD LUMP	160.76 x 35 x 14	McDermott, J. Ray, Inc.
GULF SHORE	157.13 x 35 x 14	Morgan City, La.

NAME	DIMENSIONS, ft. (LWL x B x T)	OWNER
MORNING STAR	160.76 x 35 x 14	McDermott, J. R., Inc. Equipment Leasing Division New Orleans, La.
NASHUA	95.7 x 24.2 x 8.2	Thoroughbred Marine Services,
PECTEN	96 x 22.5 x 10.5	Inc., Galveston, Texas
PIMLICO	154.58 x 38 x 12	"
NECHES	154.92 x 38 x 13	Trinity Boat Co., Inc. Houston, Texas
FRANCES CANDIES	111.55 x 25 x 13	Candies, Otto, Inc.
DORIS CANDIES	154.63 x 38 x 13	Houma, La.
BESSIE CANDIES	154.63 x 38 x 13	"
BERTILE CANDIES	161.58 x 38 x 14	"
ANNIE MAE CANDIES	163.33 x 38 x 14	"
VICKI MARIE CANDIES	156.75 x 38 x 12.5	"
ADELE CANDIES	161.58 x 38 x 14	"
AGNES CANDIES	155.13 x 38 x 13	"
AMELIA CANDIES	161.58 x 38 x 1.17	"
BEULAH CANDIES	163.33 x 38 x 14	"
IDA CANDIES	170 x 40 x 16.5	"
NORTHERN BUILDER	165.5 x 38 x 14	Tuli Holdings, Inc.
NORTHERN SUPPLIER	165.5 x 38 x 14	Chicago, Illinois
NORTHERN WORKER	165.5 x 38 x 14	"
NORTH SEAL	154.58 x 38 x 12	South Corp., Galveston, Texas
NORTH TIDE	156.17 x 36 x 12.47	Tidewater Cargoes, Inc. Morgan City, La.
OBI-1	150 x 35 x 12	Domar, Inc., Morgan City, La.
OCEAN TIDE II	165.5 x 38 x 14	Tidewater Crafts, Inc. Morgan City, La.
OWEN TIDE	87.4 x 23.1 x 9.3	Tidewater Traders New Orleans, La.
PACIFIC SEAHORSE	186 x 40 x 17	Levy, D. H. Inc.
D. M. LEVY	121 x 32 x 12	Morgan City, La
DOURADO SEAHORSE	166.92 x 38 x 13	"
PACIFIC SEAL	148.58 x 36 x 12	Seal Fleet, Inc.
CAMPECHE SEAL	154.58 x 38 x 12	Galveston, Texas
POINTE COUPEE	141.83 x 35 x 12	Global Marine, Inc. Galveston, Texas

NAME	DIMENSIONS, ft (LWL x B x T)	OWNER
HARTEBEEST	174.5 x 40 x 14	Primal Boat Company
BONGO	174.5 x 40 x 14	Port Arthur, Texas
POLAR BEAR	185.58 x 42 x 19	(New Orleans, La.)
SPRING-BUCK	174.5 x 40 x 14	"
BISON	174.5 x 40 x 14	"
GRIZZLY BEAR	185.58 x 42 x 19	"
PORTILLA	85 x 26 x 12	The Superior Oil Co., Inc. Lake Charles, La.
POWER TIDE	148.58 x 36 x 12	Tidewater Marksville, Inc. New Orleans, La.
PROVIDER	82	Dinko Smircic Corpus Christi, Texas
LINCOLN	157 x 36 x 13.5	Tidewater Venice, Inc.
BOSSIER	119.84 x 32 x 9.5	Morgan City, La.
ALL TIDE	165.25 x 38 x 14	"
RAPIDES	117.83 x 32 x 9.5	"
RICHLAND	163 x 35 x 12	"
SHAWNEE	110 x 25.5 x 10	"
CHEROKEE (Alum.)	111 x 24.2 x 10.3	"
RED BEARD	165.42 x 38 x 14	Euro-Pirates, Inc.
SIR HENRY MORGAN	170 x 40 x 17	New Orleans, La.
RED JACKET	154.58 x 38 x 12	Red Jacket Rentals, Inc. Morgan City, La.
REZA TIDE	95.44 x 25 x 12.17	Tidewater Marine, Ltd. New Orleans, La.
DARI PASSU	126.5 x 30 x 10	J&J Towing, Inc. Houston, Texas
PATHFINDER	121 x 28 x 12.25	Jake, Inc., Morgan City, La.
GULF STREAM	154.58 x 38 x 12	Dearborn Marine Service, Corp.
CAY W	154.92 x 38 x 13	Galveston, Texas
PEARL M.	111.83 x 26 x 10.11	"
ANNA M.	97 x 24.3 x 9.9	"
BIG JOE	97 x 24.3 x 9.9	"
CALIENTE	154.58 x 38 x 12	"
CAPT. CARL	111.83 x 26 x 10.11	"
CIMARRON	154.92 x 38 x 13	"
PECOS	154.92 x 38 x 13	Marine Service Co. of Houston Houston, Texas

NAME	DIMENSIONS, ft (LWL x B x T)	OWNER
KARA SEAHORSE	155 x 38 x 13	Levy Arthur Boat Service, Inc.
AEGEAN SEAHORSE	167.04 x 38 x 15	Morgan City, La.
P. E. FOOTE	166 x 38 x 14	"
ADRIATIC SEAHORSE	167.04 x 38 x 15	"
IONIAN SEAHORSE	167.04 x 38 x 15	"
RESOLUTE	178.67 x 40 x 18.5	Offshore Logistics, Inc.
P.G.T. BEAUREGARD	101.04 x 24 x 11.42	Morgan City, La.
RANGER	178.67 x 40 x 18.5	"
RELIANCE	155.6 x 38 x 12.5	"
BLACK BART	170 x 40 x 17	Slater Enterprises, Inc.
PIERRE LE GRAND	165.42 x 38 x 14	New Orleans, La.
SIR FRANCIS DRAKE	165.42 x 38 x 14	"
SIR RICHARD HAWKINS	165.42 x 38 x 14	"
ANN BONNEY	170 x 40 x 17	"
BLACKBEARD	165.42 x 38 x 14	"
JEAN LAFITTE	56.4 x 24 x 8	"
KHAIR ED DIN	165.42 x 38 x 14	"
PIKE I	149 x 34 x 11.5	Pike Corporation of America
PIKE III	140.17 x 34 x 11.5	Juneau, Alaska
ANDY MARTIN	175.44 x 40 x 17	Andy Martin, Inc. Mobile, Alabama
ANDREA MARTIN	165.42 x 38 x 14	Andrew Martin Sea Service, Inc.
RHONDA MARTIN	165.42 x 38 x 14	New Orleans, La.
ALINE MARTIN	165.5 x 38 x 14	"
RIG ENGINEER	157.58 x 36 x 15	Rig Tenders, Inc.
RIG SERVICE	141.5 x 36 x 15	Coos Bay, Oregon
RIP TIDE	119 x 32 x 8	Bisso, William A. Jr. New Orleans, La.
RIP TIDE II	165.5 x 38 x 14	Tidewater Barges, Inc. Morgan City, La.
R. J. MUNZER	156.58 x 38 x 12.46	International Boats, Inc. Morgan City, La.
ROBERT H. MCLEMORE	58 x 33.42 x 5.42	Otis Engineering Corp. Houston, Texas
ROBRAY I	157.25 x 36 x 12.5	Petty Ray Geophysical Group Division of Geosource, Int'l. New Orleans, La.
S-25	309 x 50 x 25	Raymond M. Drilling Co. Houston, Texas

NAME	DIMENSIONS, ft (LWL x B x T)	OWNER
SAFE TIDE	154.92 x 38 x 13	Tidewater Fleets, Inc. Morgan City, La.
SALTON SEAHORSE	166.33 x 38 x 13	Levy, S. A. Inc. Morgan City, La.
SAMPSON SERVICE	169.97 x 40 x 16	Sea Service, Inc. Houston, Texas
*SAMUEL P. LEE	191.29 x 39 x 21.5	Department of the Navy Survey Vessel
DEARBORN 204	181.76 x 40 x 16.5	Dearborn Marine Service Corp.
DEARBORN 203	181.76 x 40 x 16.5	Houston, Texas
SAN JACINTO	164.92 x 38 x 13	"
DEARBORN 46	154.63 x 38 x 13	"
DEARBORN 47	154.63 x 38 x 13	"
SEA INSPECTOR	87.9 x 23.1 x 6.7	Bobby Irwin, Brownsville, Texas
SEARCH TIDE	156.17 x 36 x 12.47	Tidewater Agencies, Inc. New Orleans, La.
SHAP-TIDE	166 x 38 x 13	Tidewater Development Corp., Inc. New Orleans, La.
SIRIUS	156.5 x 36 x 15	Astro-Marine, Inc.
SOUTHERN CROSS	156.92 x 38 x 15	Houston, Texas
SOUTH TIDE	142 x 33 x 10.33	Tidewater Jobs, Inc. New Orleans, La.
SOVEREIGN	164.75 x 38 x 15	Sovereign Rentals, Inc. Morgan City, La.
STAR BUCK	92.56 x 26 x 10.5	Star Fleet, Inc. Morgan City, La.
STATE ARROW	157.25 x 36 x 12.5	National Boat Company
STATE BRIGADE	170.28 x 38 x 15.93	Wilmington, Delaware
STATE COMMAND	170.28 x 38 x 15.93	"
STATE DIAMOND	165.58 x 38 x 14	"
STATE POINT	142.33 x 35 x 12	"
STATE QUEEN	155 x 38 x 13	"
STATE ROYAL	174.88 x 39 x 14	"
STATE TREASURE	165.58 x 38 x 14	"
STATE YANKEE	174.88 x 39 x 14	"
SUPER TIDE	154.17 x 38 x 12	Tidewater Ships, Inc. Morgan City, La.

NAME	DIMENSIONS, ft (LWL x B x T)	OWNER
TASK TIDE	156.17 x 36 x 12.47	Tidewater Ventures, Inc. Morgan City, La.
TASMAN SEAHORSE	155 x 38 x 13	United States Leasing Corp. Morgan City, La.
TEMAN	87 x 29 x 6.6	Diamond Services Corp. Morgan City, La.
TIMOR SEAHORSE	167.04 x 38 x 15	Levy Arthur Boat Service, Inc. Morgan City, La.
TRINITY	165 x 38 x 12.5	Offshore Logistics Services, Inc. Morgan City, La.
TROPIC TIDE	156.33 x 38 x 13	Twenty Grand Offshore, Inc. Morgan City, La.
TUNICA	120 x 25 x 11.33	Tidewater Enterprises, Inc. Morgan City, La.
U. S. OLYMPIC	157.13 x 47 x 13.77	Dresser Industries, Inc. Houston, Texas
VEN TIDE	136.08 x 35 x 11.27	Tidewater Marine Service Corp. Morgan City, La.
VIGILANT VOLUNTEER	178.67 x 40 x 18.5 178.5 x 40 x 18.5	Hartford National Bank & Trust Co. (Offshore Logistics, Inc.) Hartford, Connecticut
WAR ADMIRAL	95.3 x 20 x 9	Thoroughbred Marine Services, Inc. Galveston, Texas
WATERBUCK	154.92 x 38 x 13	Penrod Drilling Company Morgan City, La.
WESTERN BEACH WESTERN BEACON WESTERN CAPE WESTERN CAY WESTERN SEA	140.15 x 34 x 11.5 94.58 x 24 x 10.08 115.26 x 28 x 12 115.26 x 28 x 12 140.11 x 34 x 11.5	Western Geophysical Co. of America Biloxi, Mississippi " " "
WEST TIDE	132.25 x 33 x 10.33	Tidewater Exploration, Inc. New Orleans, La.
WESTWIND	152 x 23.25 x 11.5	Church, A. B., Seattle, Wash.
W. G. GINDER CASPIAN SEAHORSE	166 x 38 x 14 155 x 38 x 13	U. S. Trust Co. of New York as Trustee (E. S. C.) New York, New York

NAME	DIMENSIONS, ft (LWL x B x T)	OWNER
WIDE TIDE	142.33 x 35 x 12	Tidewater Carriers, Inc. Morgan City, La.
WILDEBEEST	174.5 x 40 x 14	Primal Boat Co., Morgan City, La.
WILLIAM DAMPIER	152.8 x 38 x 15	Atlas Offshore Boat Service, Inc. New Orleans, La.
WILLIAM P. ANDREWS	176 x 38 x 12.5	U. S. Trust Co. of New York Trustee (D.M.L.I.) New York, New York
BUFFALO	154.92 x 38 x 13	Penrod Drilling Company
YAK	180.17 x 40 x 14	New Orleans, La.
YOUNG AMERICA	183.25 x 36 x 16	Young America Rentals, Inc. Morgan City, La.
6 VC	73.5 x 26 x 5.7	Barge 6 VC, Inc. New Orleans, La.
7 VC	73.5 x 26 x 5.7	Barge 7 VC, Inc. New Orleans, La.
8 VC	73.5 x 26 x 5.7	Barge 8 VC, Inc. New Orleans, La.

* Survey Vessels fitted with passive anti-rolling tanks.

APPENDIX II

FLUME STABILIZATION SYSTEM

LIST OF INSTALLATIONS

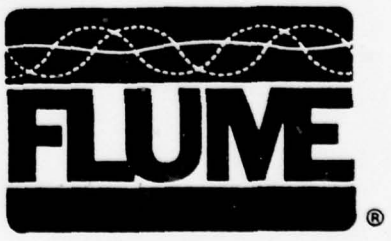
APRIL 1976

FLUME

STABILIZATION SYSTEM

LIST OF INSTALLATIONS

APRIL 1976



DESIGNED AND ENGINEERED BY
FLUME STABILIZATION SYSTEMS
A DIVISION OF JOHN J. McMULLEN ASSOCIATES, INC.
ONE WORLD TRADE CENTER
NEW YORK, N.Y. 10048

OWNER	SHIP TYPE	SIZE	NUMBER
American President Lines	PASSENGER SHIP	18,920 GRT	1
American President Lines		15,456 GRT	2
Compagnie De Navigation Paquet		9,931 GRT	1
Compagnie De Navigation Paquet		492'	1
Costa Line		20,477 GRT	1
Furness Withy & Company		13,581 GRT	1
Greek Line		17,269 GRT	1
Island Navigation Corp.		9,644 GRT	2
Japan Industry Floating Fair		12,628 GRT	1
Klosters Rederi A/S		443'	1
Klosters Rederi A/S		450'	2
Koniklijke Nederlandsche Stoomboot-Maatschappij, N.V. (Royal Netherlands Steamship Company)		7,220 GRT	1
Matson Navigation Company		18,655 GRT	1
Sovereign Cruises		433'	1
A.B. Nordo	FERRY	213'	2
A.C. Olsen		171'	1
Alaska Cruise Lines		250'	1
Ann Arbor Railroad Company		360'	1
Australian National Line		405'	3
Australian National Line		420'	1
British Railways Board		380'	1
Caronte S.P.A.		410'	2
Coast Line Co.		250'	1
D.D.R.		487'	1
Dept. of Transport (Canada)		435'	1
Dept. of Transport (Canada)		356'	1
Dept. of Transport (Canada)		375'	1
Dept. of Transport (Canada)		450'	1
Dept. of Transport (Canada)		345'	1
Dept. of Transport (Canada)		325'	1
Dept. of Transport (Canada)		328'	1
Det Forenede Dampskibs-Selskab A/S (United Danish Steamship Co.)		321'	2
Ditlev-Simonsen & Company		305'	1
General Steam & Navigation Co., Ltd.		415'	1
Isle of Scilly Steamship Co.		197'	1
Labout S.A.		264'	1
Limadet		275'	1
Ministry of Transport (Canada)		400'	1
Muroto Kisen Co., Ltd.		328'	1
Polish Ocean Lines		375'	1
Societe Anonyme De Gerance & Armament (S.A.G.A.)		415'	1
Scandinavian Shipping		263'	1
Silver Ferry		328'	1
Societa Navi Traghetto S.p.A.		384'	3
Societa Navi Traghetto S.p.A.		377'	2
Svea Shipping Company		295'	1
Svea Shipping Company		420'	1
Tokai Steamship Company		203'	1
Tokai Steamship Company		252'	1
Tokai Steamship Company		282'	1
Tor Lines		394'	4
Tor Lines		328'	2
Townsend Bros. Ferries, Ltd.		331'	1
Townsend Bros. Ferries, Ltd.		385'	1
Traghetti del Mediteranneo S.P.A.		317'	4
Traghetti Sardi S.p.A.		384'	1
Transmeditteranea		236'	1
Union Steamship Co. of New Zealand, Ltd.		440'	1
American Mail Lines Ltd.	CARGO SHIP	583'	5
American President Lines		574'	5
Ben Line Steamers, Ltd.		506'	4
China Union Lines		482'	1
Cie Navale Caenaise		425'	2
Clarke Steamship Company		471'	1
Compania Anonima Venezolana de Navegacion (Venezuelan Line)		502'	2
Delmas Vieljuex		535'	2
Delmas Vieljeux		463'	4
Finnlines Ltd.		497'	2
Flota Mercante Grancolombiana S.A.		502'	2
Fred Olsen & Company		247'	1
Globus Reedari		531'	1
Grancolumbiana		498'	1
Gydnia Nautical College		367'	1
H. Schuldt & Company		441'	6
Hudson Waterways Corp.		496'	1
Hillerstrom Shipping Company		394'	3
Hillerstrom Shipping Company		410'	2
Holland American Line		500'	1
Jan-Erik Dyvi		423'	1
Jan-Erik Dyvi		525'	2
Kawasaki Kisen Kaisha Company Ltd.		538'	3
KKK		426'	1
Koninklijke Nederlandsche Stoomboat-Maatschappij N.V. (Royal Netherlands Steamship Co.)		430'	2
Koninklijke Nederlandsche Stoomboat-Maatschappij N.V.		502'	2
Leif Hoegh & Company		476'	3
Ocean Transport and Trading Co.		508'	4
Peralta Shipping Company		453'	1
Polish Ocean Lines		501'	1
Prudential Grace Lines, Inc.		507'	2
Societe Naval Caennaise		420'	2
States Steamship Company		544'	5

OWNER	SHIP TYPE	SIZE	NUMBER
Swedish Gulf Lines	CARGO SHIP (CONT'D)	309'	2
Szcecin Nautical College		367'	2
Union Steamship Co., of New Zealand, Ltd.		250'	1
United Baltic Corporation		337'	1
Vesteraalens Damskibsselskab		452'	3
Wallenius Lines		243'	2
Geest Industries Ltd.	CARGO SHIP REFRIGERATED	443'	6
H. Schuldt & Company		443'	5
Naviera Vizcaina		450'	2
Salenrederierna A/B		450'	7
Salenrederierna A/B		420'	3
Salenrederierna A/B		410'	2
Salenrederierna A/B		490'	4
Salenrederierna A/B		525'	8
Sudoimport		503'	2
Sudoimport		503'	2
Sudoimport		503'	3
Sudoimport		503'	3
Sudoimport		504'	2
Sudoimport		459'	4
Thor Dahl A/S		390'	1
United Fruit Company		425'	1
Aznar	ROLL ON/ROLL OFF VESSEL	302'	3
Belgo Iberia		230'	2
Bore Angfartygs A/S		264'	1
Brostroms		600'	1
Eagle Lines		282'	2
East German Government		368'	1
Ellerman Wilson Line		328'	1
Framnaes		394'	2
Fred Olsen & Company		410'	3
Honda Zosen		229'	1
Jan-Erik Dyvi		423'	1
Markios Compania Naviers		328'	2
Salenrederierna		394'	4
Salen Shipping Co.		328'	1
Sudoimport		541'	4
Svenska Lloyd		381'	2
Transatlantic		600'	1
Union SS Co. of New Zealand		400'	2
Union SS Co. of New Zealand		338'	1
Wallenius Lines		600'	1
Wallenius Lines		337'	1
Wallenius Lines		262'	4
American Export Isbrandtsen Lines, Inc.	CONTAINER SHIP	560'	2
American Export Isbrandtsen Lines, Inc.		606'	6
American President Lines,		625'	3
Associated Steamship Company		514'	2
August Bolten, Wm. Millers Nachfolger		259'	2
Australian National Line		425'	1
Bahama Ocean Development Corp.		630'	4
Bristol City Line		715'	1
Central Gulf (Lash)		797'	1
Clarke Steamship Company		715'	1
Compagnie Des Messageries Maritimes		710'	2
Compagnie Maritimes Belge		715'	1
Conships		308'	3
Delta (Lash)		797'	3
D. Oltmann		396'	2
Elken Ltd.		223'	2
Evergreen Marine Corp.		492'	4
Farrell Lines Inc.		625'	4
Farrell Lines Inc.		813'	2
Finmar		630'	2
Italian Line		629'	2
K Line		537'	1
Kawasaki Kisen Kaisha		574'	1
Lloyd Triestino		630'	3
Messageries Maritimes		697'	1
Midsea Containership		420'	1
Moore McCormack Lines, Inc.		520'	7
Norwegian America Line		449'	3
Orient Overseas Line		630'	1
Overseas Container Line		710'	6
Oyama		489'	2
Pacific Far East Lines		677'	2
Pacific Far East Lines (Lash)		724'	6
Prudential Grace Lines (Lash)		724'	5
Salenrederierna A/B		328'	2
Sea Land Service Inc.		469'	1
Sea Land Service Inc.		503'	1
Seatrain Lines, Inc.		560'	4
Tyndale Shipping Company		715'	1
United Baltic Corp.		312'	1
United States Lines		700'	5
United States Lines		625'	8
Wallenius Lines		600'	1
Waterman (Lash)		797'	3
Zim Lines		630'	2
Zim Lines		485'	4
Zim Lines		675'	2
Australian National Lines	BULK CARRIERS	10,000 DWT	1
Chargeurs Reunis		15,000 DWT	1
Ditlev-Simonsen & Company		70,000 DWT	1

OWNER	SHIP TYPE	SIZE	NUMBER
Gotaas-Larsen, Inc.	BULK CARRIERS (CONT'D)	16,000 DWT	1
Hagb Waag		70,000 DWT	2
I.M. Skaugen & Company		31,000 DWT	1
Leif Hoegh & Company		22,300 DWT	3
Leif Hoegh & Company		93,000 DWT	2
National Bulk Carriers, Inc.		52,000 DWT	1
Odd Godager & Company		24,000 DWT	1
Penn Shipping Company		15,200 DWT	2
Union Navale		16,000 DWT	3
Christian Haaland	TANKER	70,000 DWT	1
Ditlev-Simonsen & Company		70,000 DWT	2
Esso International Inc.		49,000 DWT	5
Esso International Inc.		90,000 DWT	1
Esso International Inc.		48,000 DWT	1
Esso International Inc.		65,000 DWT	4
Esso International Inc.		78,000 DWT	1
Esso International Inc.		41,000 DWT	1
Esso International Inc.		71,000 DWT	2
Esso International Inc.		75,000 DWT	1
Esso International Inc.		171,000 DWT	5
Esso International Inc.		21,000 DWT	4
Esso International Inc.		140,000 DWT	2
Esso International Inc.		252,000 DWT	13
Esso International Inc.		240,000 DWT	6
Esso Petroleum Co., Ltd.		48,000 DWT	1
Esso Petroleum Co., Ltd.		90,000 DWT	1
Esso Petroleum Co., Ltd.		84,000 DWT	1
Esso Tankschiff Reederei		90,000 DWT	1
Falcon Tankers Ltd.		33,000 DWT	4
Fred Olsen & Company		72,000 DWT	1
Hagb Waage		100,000 DWT	3
I.M. Skaugen & Company		68,000 DWT	1
Imperial Oil Company		100,000 DWT	1
Island Navigation Corp.		55,000 DWT	1
Island Navigation Corp.		118,000 DWT	1
Island Navigation Corp.		73,000 DWT	1
Italcantieri		252,000 DWT	2
Kurz & Co., Charles		37,750 DWT	1
Leif Hoegh & Company		85,000 DWT	1
Leif Hoegh & Company		85,500 DWT	1
Liberian Steamship Co. of 1958		69,000 DWT	1
Manhattan Tankers, Inc.		106,000 DWT	1
Mobil Oil Company, Inc.		81,000 DWT	1
Mobil Oil Company, Inc.		95,000 DWT	3
Mobil Oil Company, Inc.		210,000 DWT	2
National Transport Corp.		73,000 DWT	1
Naviera Vizcaina		65,000 DWT	1
N.R. Bugge		43,550 DWT	1
Odd Berg		91,000 DWT	1
Pack & Kahn		171,000 DWT	1
Petrofina S.A.		227,000 DWT	2
Regent Petroleum Tankship Co., Ltd.		101,500 DWT	1
Salenrederierna A/B		40,000 DWT	2
Salenrederierna A/B		57,000 DWT	2
Salenrederierna A/B		113,000 DWT	2
Salenrederierna A/B		91,000 DWT	3
Salenrederierna A/B		216,000 DWT	1
Sarom		81,000 DWT	3
Sarom		227,000 DWT	2
Siciloil		140,000 DWT	1
S.I.R.		252,000 DWT	2
SNAM S.p.A.		254,000 DWT	2
Soc. S. LLI Cameli		81,000 DWT	5
Soc. S. LLI Cameli		227,000 DWT	1
Soc. S. LLI Cameli		254,000 DWT	2
Shell Tankers, Ltd.		49,000 DWT	2
Texaco, Inc.		249,000 DWT	1
Texaco, Inc.		101,500 DWT	1
Trelleborg Steamship Company		91,000 DWT	1
United Tankers, Inc.		37,750 DWT	2
Westwater Shipping Company		78,600 DWT	1
Wilh. Wilhelmsen		78,000 DWT	1
El Paso Natural Gas Company	LIQUID GAS TANKER	872'	2
El Paso Natural Gas Company		949'	3
El Paso Natural Gas Company		932'	3
Esso International Inc.		640'	4
Marathon Oil Company		755'	2
Aquatic Exploration Co.	RESEARCH VESSEL	185'	1
D.O.E. (Canada)		140'	1
D.O.E. (Canada)		187'	1
D.O.E. (Canada)		210'	1
Department of Mines & Technical Surveys (Canada)		285'	2
Department of Mines & Technical Surveys (Canada)		211'	2
Department of Mines & Technical Surveys (Canada)		130'	1
Department of Transport (Canada)		404'	2
Department of Transport (Canada)		187'	1
Department of Transport (Canada)		210'	1
Department of Fisheries (Canada)		130'	1
Government of Brazil		162'	1
Government of France, National Ministry of Transport		220'	2
Government of France, Oceanographic Research Department		131'	1
Government of France, Postal and Telegraph Ministry		210'	1
Italian Navy		246'	1
Lamont Geological Observatory of Columbia University		184'	1

OWNER	SHIP TYPE	SIZE	NUMBER
Mobil Oil Company, Inc.	RESEARCH VESSEL (CONT'D)	165'	2
Norwegian Ministry of Fisheries		216'	1
Norwegian Navy		131'	1
O.N.G.C. (India)		175'	1
S.M.C.B.		131'	1
Seismic Engineering Company		156'	1
Shell Oil Company		179'	3
Spanish Navy		168'	2
State Boat Corp.		125'	1
Swedish Board of Shipping		169'	1
Texaco, Inc.		165'	1
Texas A & M Research Foundation		170'	1
Tracor M.A.S.		141'	1
U.S. Dept. of Interior, Fish & Wildlife Service		147'	1
A.F. Klaveness & Co. A/S	OFFSHORE OIL VESSELS	538'	1
Atlantic-Pacific Marine		316'	1
Brunei Shell Petroleum		276'	1
Global Marine Inc.		196'	1
Jadewerft		200'	1
Luzon Stevedoring Co.		222'	1
Navifor		316'	1
Neddrill (NSU)		495'	2
Offshore Company		320'	1
Offshore Company		341'	1
Offshore Company		356'	1
Olsen & Ugelstad		550'	1
P & O Offshore Services, Ltd.		188'	1
P & O Offshore Services, Ltd.		145'	1
P & O Offshore Services, Ltd.		141'	1
P & O Offshore Services, Ltd.		150'	1
Petrobras		364'	1
Reading & Bates Exploration Co.		503'	1
Saipem		400'	1
Salvesen		359'	1
Southeastern Drilling Inc.		200'	2
Storm Drilling Co.		359'	1
Storm Drilling Co.		360'	1
Tidewater		218'	2
Triton Industries		260'	1
Westburn		418'	1
Western Offshore		470'	1
Western Offshore		520'	1
Zapata Offshore Company		407'	1
Zapata Offshore Company		200'	4
Zapata Offshore Company		515'	1
Zapata Offshore Company		206'	2
Zapata Offshore Company		183'	4
Canadian Government	ICEBREAKER	289'	2
Canadian Government		549'	1
Department of Transport (Canada)		250'	1
Department of Transport (Canada)		334'	1
Department of Transport (Canada)		297'	1
Department of Transport (Canada)		290'	1
Department of Transport (Canada)		310'	1
Department of Transport)Canada)	BUOY TENDERS	249'	1
Department of Transport (Canada)		201'	3
Department of Transport (Canada)		165'	1
Department of Transport (Canada)		170'	2
Department of Transport (Canada)		184'	3
Department of Transport (Canada)		204'	1
Department of Transport (Canada)		212'	1
Department of Transport (Canada)		229'	1
Department of Transport (Canada)		259'	1
Department of Transport (Canada)		289'	2
Cable & Wireless, Ltd.	CABLE SHIP	375'	1
Department of Transport		276'	1
General Post Office, Great Britain		291'	1
General Post Office, Great Britain		340'	1
General Post Office, Great Britain		450'	2
Trans Oceanic Cable		447'	1
Alcott, R.	FISHING VESSELS	201'	1
American Stern Travelers		263'	2
Andrade, M.		225'	1
Armamento e di Pesca		240'	1
Banfoco		156'	6
Bonavista Cold Storage		145'	4
Brito, L.		152'	1
Brumble Bee Seafoods		191'	1
Calypso Tuna		201'	1
Castagnola, L.		171'	1
CIE, Navale Caenaise		184'	1
Delta Fishing		225'	1
Epsilon Fishing		225'	1
Eta Fishing		225'	1
Fernandez, M.		201'	2
Gann Enterprises		201'	2
Gann Enterprises		191'	1
Gann Enterprises		152'	1
Gann Enterprises		237'	1
Gann Enterprises		203'	1
Granit A/S		203'	1
Hansen, A.		163'	1
Huse I/S		139'	1
Italo-Congolese		240'	1

OWNER	SHIP TYPE	SIZE	NUMBER
Lococco, A.	FISHING VESSELS (CONT'D)	240'	1
Madruga, J & R		191'	1
Madruga, J & R		184'	1
Madruga, J & R		203'	1
Maritima de Axpe		221'	1
Martinac		223'	4
Martinac, J.M.		203'	3
Martinac, J.M.		223'	4
Medina, H.		162'	1
Mexican Government		181'	3
Mexican Government		156'	6
National Marine Term.		201'	2
Navexport		221'	2
Noratun		206'	1
Ocean Fisheries Inc.		184'	2
Ocean Fisheries Inc.		203'	1
Ocean Fisheries Inc.		191'	1
Ove Hoegh		260'	1
Partrederiert, Pero, P. & R. Vartdal		169'	1
Pescafrisa		206'	1
Pescafrisa		216'	2
Salveira		162'	2
San Diego Marine		201'	3
SICAPE		240'	1
SICCNA		59'	5
SICCNA		180'	1
Silva, M. & Assoc.		171'	1
Soares		152'	1
Societa Italo Congolese di Armamento e di Pesca		240'	3
Sousa, G.		201'	1
Starkist Foods		201'	2
Starkist Foods		259'	1
Sudoimport		375'	3
Sudoimport		504'	2
Suratim		151'	1
Tacoma		181'	3
Tontini Pesca		310'	1
Torrison, O. & Son		146'	1
Trident Fishing		201'	2
Tunidos Congelados		250'	1
Tunidos Congelados		216'	1
Vagafisk		109'	3
Van Camp Seafood		223'	4
Vartdal Fiskkeriselskap A/S		169'	2
Voyager, Inc.		237'	1
Watt, R. A.		188'	1
Watt, R. A.		201'	1
West Indies Tuna		171'	1
Zapata		190'	1
Zapata		200'	1
Zeta Fishing		225'	1
Zollezzi, J.		152'	1
Bender Machine Works	MISCELLANEOUS VESSELS	150'	1
Bernard Hansen		150'	4
Blue Star		273'	1
Brazilian Navy		225'	1
Calcutta Port Commission		250'	2
Department of Environment (Canada)		154'	1
Department of Transport (Canada)		150'	1
Department of Transport (Canada)		215'	2
Department of Transport (Canada)		230'	1
Department of Transport (Canada)		75'	1
General R. Johnson		177'	1
H.M. King of Norway		247'	1
Hong Kong Government		95'	2
Koninklijke Onderwijsfonds Voor De Scheepvaart (K.O.F.)		196'	1
Luzon Stevedoring Company		497'	1
Micoperi Marche		623'	1
Ministry of Transport, United Kingdom		360'	3
Mme. Renault		148'	1
National Aeronautical and Space Administration (N.A.S.A.)		196'	2
Polish Ocean Line		367'	3
Rijkswaterstaat		246'	1
Royal Belgian Navy		285'	1
Royal Norwegian Lifeboat Inst.		92'	1
Royal Norwegian Navy		178'	2
Royal Norwegian Navy		308'	5
Sandy Hook Pilots		162'	1
Societe Naval Caennaise		420'	2
Sudoimport		687'	2
Sudoimport		377'	8
Swedish Board of Shipping		128'	1
Transmarine Corp.		177'	1
Trenora Shipping		195'	1
U. S. Coast Guard		350'	1

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APPENDIX III

QUESTIONNAIRE SENT TO OFFSHORE SUPPLY VESSEL BUILDERS AND OPERATORS

giannotti & buck associates, inc.

NAVAL ARCHITECTS • OCEAN ENGINEERS • MARINE ENGINEERS

Dear

Giannotti & Buck Associates, Inc. is under contract to the Naval Sea Systems Command, PMS 383, to conduct a survey of operating experiences with passive anti-rolling tanks. Although the survey is intended to be quite general the specific motivation for this task lies in interest in moderating the rolling motions of the T-AGOS, a 204-ft oceanographic survey ship with an Offshore Supply Boat type hull now in preliminary design and scheduled for procurement in FY- .

We would value your help and comments in providing this information to NAVSEA. In particular we have several questions which we have listed on the attached sheet. If you could take just a few moments to pencil in your comments on as many of the questions on which you may have information it will be very much appreciated by us and will be of help to NAVSEA in developing an effective preliminary design. If you have access to arrangement drawings or sketches of OSB's in this size range which would help us in evaluating the impact of incorporating a passive anti-rolling system in this type of ship, this also would be of great help.

In busy days such as these it is difficult to find time to devote to a request such as this. Please know in advance that we deeply appreciate your help.

Sincerely,

Julio G. Giannotti, Ph.D.
President

CRESTWOOD BUILDING, SUITE 402 • 5711 SARVIS AVENUE • RIVERDALE, MARYLAND 20840 • (301) 927-3200

ANTI-ROLL TANK QUESTIONNAIRE

Giannotti & Buck Associates, Inc.
5711 Sarvis Avenue, Suite 402
Riverdale, Maryland 20840

1. Please give your name, position and company.

2. Do you have personal knowledge of any ships of the offshore supply boat type that are fitted with passive anti-rolling tanks?

Ship's Name	Length	Master	Retrofit or Original Installation

3. Do you have personal knowledge of other small ships, 90' - 250', that are fitted with passive anti-rolling tanks?

Ship's Name	Length	Type Ship	Master	Retrofit or Original Installation

4. Have the installations with which you are familiar been in continuous operation, or have they been inactivated part-or-all of the time? If so, why? What percentage of the time would you estimate the tanks have been used?

5. Have the installations been found to be effective over a range of sea states, speeds, headings and loading conditions, or is their effectiveness limited to just certain conditions?

6. What has been the response of master and crew to the passive anti-rolling tank stabilization system? Has there been a noticeable increase in crew effectiveness?

7. Has the overall operational effectiveness of the ship(s) been materially increased by the tank installation? Can the ship(s) with tanks operate effectively under conditions which would reduce its effectiveness without tanks?

8. Do you personally have any complaints, or do you know of complaints about anti-rolling tank installations?

9. What is your personal evaluation of the trade-off between the roll reduction achieved, the percentage of time that roll reduction is important, and the penalty on the ship's volumetric capacity imposed by the tank installation? Are they worth the price in terms of capacity and in terms of cost?

10. Do you have any other comments?

APPENDIX IV

LETTER FROM MR. W. THOMAS BALLANTINE, JR.

VICE PRESIDENT OF ENGINEERING AND MAINTENANCE,

ZAPATA MARINE SERVICE, INC.

WM THOMAS BALLANTINE, JR
Vice President
Engineering and Maintenance

Zapata Marine Service, Inc.

April 28, 1977

Giannotti and Buck Associates
5711 Scarvis Avenue
Suite 402
Riverdale, Maryland 20840

Attention: Dr. J. Giannotti

Gentlemen:

Zapata Marine Service, Inc. operates a fleet of approximately forty-eight offshore service vessels. These vessels include crew boats, tugs, supply boats and anchor handling tug-supply vessels. The majority of the fleet is made up of the latter type.

Several of our vessels are equipped wit. passive, anti-roll stabilization tanks. Our vessels that do have this system are equipped with the Flume design. The following Zapata Marine vessels are so equipped:

M/V MAJESTIC SERVICE	M/V CONSTITUTION SERVICE
M/V IMPERIAL SERVICE	M/V INDEPENDENCE SERVICE
M/V PARAMOUNT SERVICE	Campbell Industries Hull 118 (FREEDOM)
M/V AMBASSADOR SERVICE	Campbell Industries Hull 119 (HERITAGE)
M/V SOVEREIGN SERVICE	Campbell Industries Hull 120 (LIBERTY)
M/V STATESMAN SERVICE	Campbell Industries Hull 121 (PIONEER)
M/V DOMINION SERVICE	

All of the above vessels have a molded hull type construction with bilge keels.

The following vessels have been built with a single chine type construction:

M/V VIKING SERVICE	M/V VICTORY SERVICE
M/V THOR SERVICE	M/V VALIANT SERVICE
M/V SAXON SERVICE	M/V VENTURE SERVICE
M/V SCANDIA SERVICE	M/V VIGILANT SERVICE
M/V COLUMBIA SERVICE	M/V HERCULEAN SERVICE
M/V REPUBLIC SERVICE	M/V SPARTAN SERVICE

These vessels do not have any type of stabilization system.

April 28, 1977

The remainder of the Zapata Marine fleet is made up of varying designs, the majority of which approach the chine type definition. Again, none of these vessels has any type of stabilization system installed.

In general, it is our philosophy that if we build a chine boat we would not install a passive anti-roll stabilization tank. However, in discussions with our Senior Naval Architect, Mr. James W. Gray, after our telephone conversation, he indicated that we would want to review and test a hard chine configuration, if the overall length was 200 ft. or greater. Any vessel of substantial size with a molded hull would be constructed with some type of stabilization system.

Very truly yours,

W. T. Ballantine, Jr.

WTB/vmg
cc: Mr. James W. Gray, Zapata Marine Senior Naval Architect

APPENDIX V

CHARACTERISTICS OF THE OFFSHORE SUPPLY VESSEL STAR ARCTURUS

Star Arcturus

Builders
Smith's Dock Company Ltd., Southbank, Middlesbrough

Principal Dimensions
Length Overall 266ft 0in 81.00m
Breadth Moulded 56ft 7in 17.25m
Depth Moulded 22ft 10½ in 7.00m
Draught (service) 15ft 0in 4.70m
Gross Tonnage 1550 tonnes

Cargo Capacity
Deadweight 2750 tons
Deck Cargo 2000 tons
Deck Space 180ft × 48ft 8,640 sq ft
Fuel 935 tons
Drill Water 2090 tons
Fresh Water 219 tons
Bulk Chemicals 6000 cu ft

Refrigerated Storage Capacity
Deep Freeze 300 cu ft – 20°C
Cool Room 300 cu ft + 1°C

Accommodation
Officers and Crew 12
Passengers 12

Air Conditioning
Vessel is fully air conditioned for hot and cold climates

Wheelhouse
Complete remote control of main engines and bow thrust. Forward and aft control positions.

Navigational Equipment
Radar, Direction Finder, Echo Sounder, Gyro Compass, Autopilot, Radio Telephone and VHF Telephone, MK21 Decca Navigator.

Anchors and Cables
2 high holding power with adequate high tensile steel studlink chain cable. 1 spare anchor.

After Capstains
1 Port and 1 Starboard

Sliding Deck
Forward two sections movable (each independent of the other).

Rudder
2 Becker type rudders enabling ship to produce 35,000lbs lateral thrust.

Propulsion
2 British Polar Diesel Engines 12cyl. 4 stroke F.212 VA825 total 4600 BHP.

Auxiliaries
3 × 170kW Generators driven by Caterpillar diesel engines

Cargo Pumps
1 Fuel Cargo Pump
100 tons/hr 25400 US Galls/hr at 200ft Head
1 Freshwater
100 tons/hr 22400 US Galls/hr at 200ft Head
1 Drillwater
250 tons/hr 56000 US Galls/hr at 200ft Head
1 General Service Pump 100 tons/hr

Compressor for Cargo Pressure Tanks
1 compressor capable of delivering 30 tons/hour at 140ft head

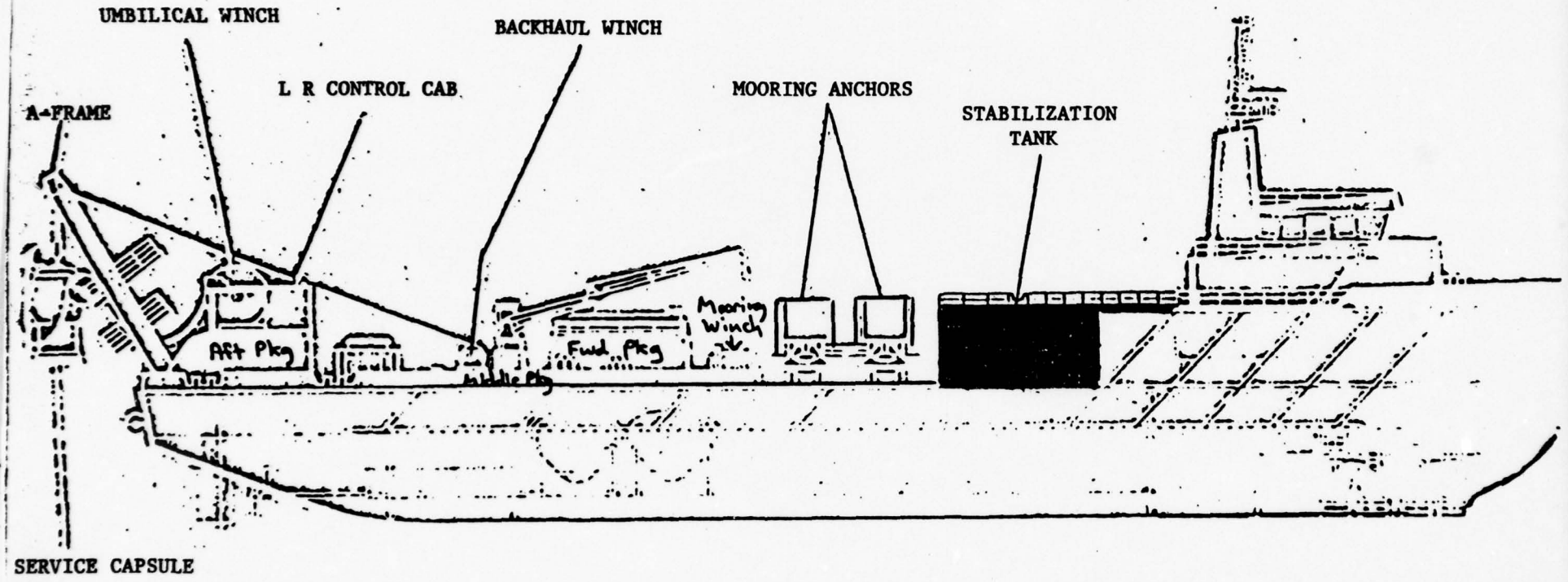
Bow Thrust Unit
2 × 50in Gill Jets each 630 BHP producing a total of 22,500lbs thrust.

Speed and Consumption
Trial speed loaded 14.0 knots using approximately 16 tons per day.
Service speed 13 knots using approximately 14 tons per day.

Star Arcturus and her sis ship Star Canopus are a new generation of specialist pipe carrying vessels which have b designed to give the charterer the maximum amount of deck for the most economic rate.

Built to Lloyds highest class + 100 A1, and DTI class VII Star Arcturus is designed to service offshore rigs and platforms in waters anywhere in the world.

She is able to carry in ex of one mile of pipe, putting her among the largest supply vessels currently in operatio


UMBILICAL WINCH
BACKHAUL WINCH
L R CONTROL CAB
MOORING ANCHORS
A-FRAME
STABILIZATION TANK
Aft Pkg
Fwd Pkg
Mooring Winch
SERVICE CAPSULE

APPENDIX VI

ROLL STABILIZATION BIBLIOGRAPHY

21 130682

ROLL COMPUTER

Russ, JE

PUBLICATION:
Department of the Navy; Washington, D.C.; 130682

Patent; #AD-D001 361/5; 12 Nov 74; 4 pp
#PAT-APPL-415 693

SUMMARY:
The patent relates to a device whereby a ship mounted stabilizer roll tank is instrumented to generate signals indicative of the tank moment. The ship is also instrumented to generate signals indicative of its actual roll. The measured tank moment is weighted to yield a signal indicative of the difference between the actual stabilized roll and the estimated unstabilized roll.

SUPPLEMENTAL NOTE:
Government-owned invention avilable for licensing. Patent application filed 14 Nov 73.

SOURCE:
National Technical Information Service

ORDER FROM:
Commissoner of Patent; Washington, D.C.; 20231; Repr. PC; $0.50; PATENT-3 847 348

21 130679

DEVELOPMENT OF A TECHNICAL PRACTICE FOR ROLL STABILIZATION SYSTEM SELECTION. PHASE 1

Miller, ER
Slager, JJ
Webster, WC

PUBLICATION:
Hydronautics, Incorporated; 7210 Pindel School Road; Laurel, Maryland; 20810

Tech. Rpt.; #TR-7401.06-1; Oct 74; 114 pp
#NAVSEC-6136-74-280

FT-Contract; CN-N00024-73-C-5572

SUMMARY:
The determination of required roll motion performance or maximum permissible ship rolling, for a given application, is considered. The influence of human effectiveness and subsystem performance on this determination is discussed. Methods are given for the evaluation of and selection of the best type or types of roll stabilization systems for a given ship. Means are provided for assessing the size and weight of various roll stabilization devices including active and passive tank roll stabilizers and active fin roll stabilizers. Means are given for estimating the damping coefficients of ships with no stabilization systems or with bilge keels only. Typical roll motions for various sea conditions, ship headings and ship speeds can be estimated from the extensive calculated results presented for destroyer and auxiliary type ships with and without stabilizers. /Author/

SUPPLEMENTAL NOTE:
See also AD-A017 669/3 "Phase 2, Roll Tanks".

SOURCE:
National Technical Information Service

ORDER FROM:
National Technical Information Service; 5285 Port Royal Road; Springfield, Virginia; 22161; Repr. PC; $5.50; Microfiche; $2.25; AD-A017 655/2GA

21 084513

SATISFACTORY SERVICE EXPERIENCE WITH FLUIDIC ELEMENT CONTROLLED SHIP ROLL STABILIZATION SYSTEM

PUBLICATION:
Shipping World and Shipbuilder; Benn Brothers Marine Publications Limited; Lyon Tower, 125 High Street, Colliers Wood; London SW19; England

V167 N3896; Aug 74; p 861

SUMMARY:
A motion control system for the automatic stabilization of ships whereby rolling can be reduced to a minimum even in heavy seas has been developed and is described. This system utilizes a fast-moving counterweight in the form of a mass of water stored in a U-shaped tank following the cross section of the ship. This tank is half full of water and when the ship shows signs of rolling, water is transferred from one end of the U to the other. This system can reduce a roll of 30 degrees to as little as 8 degrees. A detailed discussion on the operation of the system, as well as its various components, is included in the article.

SOURCE:
National Maritime Research Center, Kings Point; N-898

ORDER FROM:
Benn Brothers Marine Publications Limited; Lyon Tower, 125 High Street, Colliers Wood; London SW19; England; Repr. PC; Req. Price

21 057266

DEVELOPMENT OF AN AUTOPILOT TO CONTROL YAW AND ROLL

Cowley, WE; University College, London

PUBLICATION:
Naval Architect; Royal Institution of Naval Architects; 10 Upper Belgrave Street; London SW1X 8BQ; England

N1; Jan 74; pp 18-19

SUMMARY:
A research project which has been under way for four years, on the effects of rudder induced roll, is described. The type ot ship on which the rudder offered the greatest potential as a roll stabilizer was a fast container ship, and it was this type of vessel which was investigated in the research effort. The first part of this article describes the experiments which have already taken place using the rudder as a roll stabilizer, and in the latter part, the work on a combined fin and rudder controller is introduced and the potential of the rudder as a roll stabilizer reviewed.

SOURCE:
National Maritime Research Center, Kings Point; N-842

ORDER FROM:
Royal Institution of Naval Architects; 10 Upper Belgrave Street; London SW1X 8BQ; England; Repr. PC; Req. Price

21 057061

DESIGN ON THE FREQUENCY PARAMETER PLANE WITH APPLICATION TO ROLL STABILIZATION OF SHIP

Vachanaratana, M

PUBLICATION:
Naval Postgraduate School; Monterey, California

MS Thesis; Dec 73; 104 pp

SUMMARY:
Frequency parameter plane techniques are developed for the analysis and synthesis of both linear and nonlinear systems. The transmission function of a dynamic system contains two parameters which are adjusted to provide desired performance. These parameters represent elements of the system. The four dimensional parameter space relating magnitude, frequency, and the two parameters may be represented by seven two dimensional projections of the parametric curves. Computer programs are developed for the computation, and graphs of results are obtained. Interpretations of the graphs can be used for design of systems such as tank stabilizers. (Author)

SOURCE:
National Technical Information Service; AD-775040/9; u7409

ORDER FROM:
National Technical Information Service; 5285 Port Royal Road; Springfield, Virginia; 22151; Repr PC; $8.25; Microfiche; $1.45; AD-775040/9

21 057043

ANALYSIS OF ROLL STABILIZER PERFORMANCE

Van Gunsteren, FF; Royal Netherlands Shipbuilding Association;

PUBLICATION:
International Shipbuilding Progress; International Periodical Press; 194 Heemraadssingel; Rotterdam, Holland; Netherlands;

V21 N237; May 74; pp 125-146; 20 Ref.

SUMMARY:
A short review of the mathematical formulation of the seaway and the ship motion responses with special reference to rolling is given, where as measures of effectiveness of roll damping devices are briefly discussed. Full scale rolling experiments with a motoryacht in still water and in waves are analyzed. The performance and design of fin-stabilizers is dealt with on the basis of experimental results and common hydrodynamic knowledge. The use of rudders as roll stabilizers seems to be rather promising according to full scale motoryacht experiments.

SOURCE:
International Periodical Press

ORDER FROM:
International Periodical Press; 194 Heemraadssingel; Rotterdam, Holland; Netherlands; Repr PC; Req Price

21 051102

EXPERIMENTAL AND MATHETICAL MODELLING OF FLUME ANTI-ROLL TANKS FOR SHIPS

Black, HF; Heriot-Watt University
Hartnup, GC

PUBLICATION:
American Society of Mechanical Engineers; 345 East 47th Street; New York, New York; 10017

Paper; #73-DET-71; 8 pp; 7 Ref

SUMMARY:
Describes an approach to assessing the performance of flume antiroll tanks. A rolling frame for testing models up to 6 ft. 0 in. beam together with an analog and control system enabling the frame to be used as a ship roll simulator, is described. A linearized mathematical model of fluid motion in a flume is presented. An empirical representation of the principal nonlinearity of flumes is then added. Harmonic responses of a model flume, both with constant amplitude forced rolling and incorporated in a ship simulation, are presented and compared with the mathematical model.

SUPPLEMENTAL NOTE:
Prepared for meeting 9-12 September 1973.

SOURCE:
Engineering Index; EI 73 059352

21 054390

ON THE EQUATIONS OF MOTION OF SHIPS EQUIPPED WITH AN ANTI-ROLLING TANK IN BEAM SEAS

Hirana, M

PUBLICATION:
Japan Shipbuilding and Marine Engineering; Japan Association for Technical Information; 4-7-107, Yamazaki-cho, Machida City; Tokyo 194-01; Japan

V7 N2; 73; pp 21-26; 8 Ref

SUMMARY:
There have been made many studies about an antirolling tank. In most of those studies only the coupling effect between rolling motion and tank fluid motion has been considered using Froude-Kriloff's assumption. This may be the reason among others, no established satisfactory theory about ship motions except rolling motion has been developed. In general, a ship laid broadside on regular progressive waves performs not only rolling but also heaving, pitching, surging, swaying, yawing and drifting motion. In recent years, it has become possible to treat these motions applying the wave making theory for radiation forces and wave exciting forces. In this report, the ship-tank equations of motion are developed based on Tasai's theory about ship motions in beam seas and the comparisons are made with other theories.

SOURCE:
Department of Transportation

ORDER FROM:
Japan Association for Technical Information; 4-7-107, Yamazaki-cho, Machida City; Tokyo 194-01; Japan; Repr PC; Req Price

21 050517

DETUNING TANK--AN EFFECTIVE STABILIZING DEVICE

Garcia, EC; Breit Engineering Incorporated

PUBLICATION:
Society of Petroleum Engineers Journal; Society of Petroleum Engineers; 6200 North Central Expressway; Dallas, Texas; 75206

V13 N1; Feb 73; pp 48-56; 4 Ref

SUMMARY:
The concept of the detuning tank is advanced. The system is different from others in the sense that it does not try to compensate the action of the forces imparted by the sea to the floating body with properly phased compensating forces, but tries to prevent the sea from imparting the forces to the body. The effectiveness of such tanks has been experimentally verified in model basin motion tests and studies.

SUPPLEMENTAL NOTE:
Original version of this paper (SPE 3405, OTC 1415) was presented at the Third Annual Offshore Technology Conference, Houston, Texas, April 19-21, 1971.

SOURCE:
Engineering Index; EI 73 046797

21 050508

EXPERIMENTAL EVALUATION OF A PASSIVE ANTI-ROLL TANK SYSTEM

Plank, WS; Oregon State University
Beardsley, GF, Jr
Burt, WV

PUBLICATION:
Ocean Engineering; Pergamon Press; Maxwell House, Fairview Park; Elmsford, New York; 10523

V2 N3; Sep 72; pp 131-139; 7 Ref

SUMMARY:
The effectiveness of the passive anti-roll tank system aboard the R/V Yaquina was determined. Measurements of ship roll, effective waveslope and tank water transfer were analyzed using a systems analysis technique. Time series of the inputs and outputs of the ship tank system and of the tank itself were processed using spectral analysis methods to obtain system transfer functions for stabilized and unstabilized configurations. Comparison of these transfer functions showed that the anti-roll tank system has a significant and beneficial effect on the rolling performance of the vessel. However, all tests were made with seas approaching on the beam and therefore, no conclusions about the tank's effectiveness in reducing yaw-heel rolling, especially very long period rolling resulting from follwing seas can be made.

SOURCE:
Engineering Index; EI 73 046796

20 044418

THE DESIGN OF U-TANKS FOR ROLL DAMPING OF SHIPS

Van Den Bunt, JD; Delft Hydraulics Laboratory

PUBLICATION:
Netherlands Ship Research Center TNO; Delft; Netherlands

N67; Nov 69; 18 pp; 9 Ref

SUMMARY:
The first part of the report deals with new developments in U-tanks, such as the correction of some of the coefficients in the equations of motion. Also the digital computer can be used in the computation of the movements of the ship and tank fluid. The procedure of obtaining optimum stabilization has been altered radically. The shape of the U-tanks has been changed also. The roll-damping efficiency of the U-tank for a ship with strongly variable loading conditions has been examined and a solution for the adaptation of the U-tank to the loading conditions has been found. The second part of the report gives some information concerning the data of ship and sea which are needed for designing a U-tank. Also a short description of the efficiency of the U-tank, dependent on space available and loss of static stability that can be afforded, and depending on the loading condition of the ship has been given. The illustrating figures giving curves of rolling angles have all been obtained by computations. Only rolling motions due to long crested, regular, beam waves have been considered.

SUPPLEMENTAL NOTE:
Reprint from Netherlands Ship Research Center TNO, Report #124 S, October 1969.

SOURCE:
National Maritime Research Center, Galveston

ORDER FROM:
Netherlands Ship Research Center TNO; Delft; Netherlands; Repr PC; Req Price

21 040897

COMPARATIVE PERFORMANCE OF ROLL STABILIZATION SYSTEMS FOR THE PATROL FRIGATE

Miller, ER, Jr
Lain, H

PUBLICATION:
Hydronautics, Incorporated; Pindel School Road; Laurel, Maryland

Tech Rpt; #TR-7103-3; Mar 72; 150 pp

FI-Contract; CN-N00014-71-C-0080

SUMMARY:
The results of a study of the comparative performance of possible roll stabilization systems for the Patrol Frigate are presented. An initial screening process was carried out in which the following systems were considered: bilge keels, free surface anti-roll tanks, u-tube anti-roll tanks, active anti-roll tanks, moving weight stabilizer, and active fins. Based on this screening process more detailed studies were carried out using bilge keels and bilge keels in combination with free surface and U-tube anit-roll tanks and active fins. These studies covered a range of system sizes and performance estimates for a range of sea states, speeds and heading angles. The results are presented in terms of the size and weight of each system and the roll motions of the ship for the range of sea state, speeds and heading angles. Cross plots are also presented to facilitate comparison between different systems.

SUPPLEMENTAL NOTE:
See also MRIS #034467, Volume 6.

SOURCE:
National Technical Information Service; AD-745376

ORDER FROM:
National Technical Information Service; 5285 Port Royal Road; Springfield, Virginia; 22151; Repr PC; $3.00; Microfiche; $1.45; AD-745376

21 034476

THE ANTI-ROLL STABILIZATION OF SHIPS

Escalona, JR

PUBLICATION:
Naval Postgraduate School; Monterey, California

MA Thesis; Jun 71; 109pp

SUMMARY:
The theory of roll stabilization of ships is presented in the context of modern control theory. The most common systems used to reduce that roll are described, and the principal equations are formulated. A general approach for the analysis of roll stabilizers is developed and applied to an activated fin stabilizer system. For this approach parameter plane techniques were applied, and the system was simulated in a digital computer. A system is proposed which is intended to improve the performance of passive tank stabilizers.

SOURCE:
National Technical Information Service; AD-738869

ORDER FROM:
National Technical Information Service; 5285 Port Royal Road; Springfield, Virginia; 22151; Repr PC; $3.00; Microfiche; $1.45; AD-738869

21 032665

DEVELOPMENT AND TESTING OF A PASSIVE, MOVING-WEIGHT ROLL STABILIZER FOR THE U.S.C.G. 82-FOOT CLASS PATROL BOAT

Kirkman, KL; Hydronautics, Incorporated

PUBLICATION:
Society of Naval Architects and Marine Engineers; 74 Trinity Place; New York, New York; 10006

7243; 50pp; 3 Ref

SUMMARY:
The United States Coast Guard 82-Foot Class of patrol vessels typify potentially suitable applications for a passive, moving-weight roll stabilizer system. As a result of an internal development program, Hydronautics, Incorporated produced a pilot model of such a system and, in cooperation with the Coast Guard, installed this unit aboard a vessel for full scale trials. The paper briefly describes the design development, and a series of simulations, hydrodynamic model tests, and mechanical tests. The program of full-scale trials is presented, and trial result are summarized which correlate with engineering predictions and demonstrate marked roll motion reductions. Brief comparisons with common stabilization methods are also presented.

SUPPLEMENTAL NOTE:
Prepared for presentation to Chesapeake Section of The Society of Naval Architects and Marine Engineers, March 21, 1972, Washington, D.C.

SOURCE:
Society of Naval Architects and Marine Engineers

ORDER FROM:
Society of Naval Architects and Marine Engineers; 74 Trinity Place; New York, New York; 10006; Repr PC; Req Price

21 032157

NEW STABILIZER CONTROL SYSTEM FOR LARGE SHIPS

Tann, A

PUBLICATION:
Marine Engineer and Naval Architect; Whitehall Technical Press Limited; Wrotham Place; Wrotham Sevenoaks, Kent; England

V94 N1138; Jan 71; pp28-9

SUMMARY:
This is a new development by Muirhead Ltd of Beckenham, England. Designated the New Multra K-373, it has been introduced to take advantage of modern techniques to simplify existing designs and dependent upon the control system, which determines at every instant the angle of attack of the fins. For optimum performance it is necessary for the computed control signal to comprise components proportional to roll angle, roll velocity and roll acceleration. Since the lift generated by the fins is proportional to the square of the ship's speed it is necessary to reduce the maximum fin angle at speeds in excess of the design speed to prevent instability and overloading. This function is performed electronically on the combined signal before the signal is passed to the main amplifier which provides outputs for up to four fins. The equipment has been designed to accommodate any type of servo valve likely to be used to control the flow rate in the hydraulic cylinders of vane motors used to operate the fin.

SOURCE:
Engineering Index; EI 72 05572

21 019363

SELECTION OF A SHIP'S STABILIZER

Rorke, J
Volpich, H

PUBLICATION:
Institute of Marine Engineers-Transactions; Memorial Building, 76 Mark Lane; London EC3; England

V82 N9; Sep 70; pp329-43; 6 Ref

SUMMARY:
The paper is intended to deal with the practical aspects of the selection of a stabilizer for a specific type of vessel, providing the shipowner or operator with guidel ines to help him in his selection. To facilitate quick appraisal of suitable types of installation, the choice of stabilizing equipment is discussed under class of ship. Passenger liners and cruise vessels, fast cargo liners, container vessels and tankers. Car ferries and cross-channel ferries, naval vessels, trawlers and fish factory ships, yachts, and specialized craft.

SOURCE:
Engineering Index; EI 71 48076

26/05/77 MRIS RUN NO. M000199 SELECTIONS
C.I. SHIP MOTIONS - GROUP I

21 019134

CONTROL SYSTEM FOR ACTIVE FIN ROLL STABILIZATION

Tinn, SJO

PUBLICATION:
Naval Engineers Journal; American Society of Naval Engineers, Incorporated; 1012 14th Street, NW; Washington, D.C.; 20005;

V82 N4; Aug 70; pp78-85

SUMMARY:
A detailed investigation of the control problems involved in an active fin roll stabilization system is described. An optimum system has now been derived taking as its sole input a roll angle signal from the ships central weapons stabilization system (Mk. 19 compass). This signal is processed electronically to derive a control transfer function in terms of roll angle, roll velocity and roll acceleration. Other features e.g. forced roll, stabilize with list, speed compensation of loop gain, helm compensation and fin limiting as a function of ship's speed, are incorporated as are testing and fault finding facilities, and static and dynamic calibrating signals.

SOURCE:
Engineering Index; EI 71 26976

21 019362

COMPARISON OF SHIP ROLL STABILISATION METHODS

Bennett, DA

PUBLICATION:
Shipping World and Shipbuilder; Benn Brothers Marine Publications Limited; Lyon Tower, 125 High Street, Colliers Wood; London SW19; England

V163 N3847; Jul 70; 4pp

SUMMARY:
The objectives of roll stabilization are defined as they affect people and cargo. Five stabilizing systems are considered--uncontrolled passive tanks, controlled passive tanks, activated tanks, activated fins, and ballast control systems. The benefits and expense or other penalty for each system is examined. It is concluded that if the stabilizing requirement for a vessel includes a severe harbor loading problem, and a need for good rolling performance at sea, then a hybrid system of two or perhaps even three of the subject systems will be required.

SOURCE:
Engineering Index; EI 71 48347

21 014885

TANK, FIN OR HYBRID

Bennet, D

PUBLICATION:
Shipbuilding and Shipping Record; Transport and Technical Publications Limited; 161-166 Fleet Street; London EC4; England

V115 N10; 13 Mar 70; pp33-34

SUMMARY:
A number of ship roll stabilizing devices are reviewed, namely passive tanks, controlled passive tanks, activated tanks and activated fins. For each device, the scheme of operation is explained and the advantages, disadvantages and limitations are reviewed. The use of hybrid stabilizing systems with several different types of devices is mentioned.

SOURCE:
Engineering Index; EI 70 51084

ORDER FROM:
Engineering Societies Library; 345 East 47th Street; New York, New York; 10017; Repr PC; 3 + 25¢/p; Microfilm; 3 + 5¢/fr